Marine Engineering

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Fig. 1.—Italian Passenger Steamship *Giulio Cesare*

Passenger Liner Giulio Cesare

Luxurious New Italian Liner to Engage in South American Passenger Service

A NEW addition to the passenger fleet of the world is the passenger liner *Giulio Cesare,* the construction of which has recently been completed at the Wallsend Shipyard of Messrs. Swan, Hunter & Wigham Richardson, Ltd., Wallsend-on-Tyne, England.

The vessel, which was built to the account of the Navigazione Generale Italiana, Genoa, for service between Genoa and Buenos Ayres, is of the following principal dimensions:

Length overall	632 feet 11	inches
Length between perpendiculars	601 feet 5	inches
Breadth, molded	76 feet 0	inches
Depth, molded to awning deck	53 feet 2⅜	inches

The *Giulio Cesare* was designed to meet the highest class of the Registro Nazionale Italiano, British Corporation and Lloyd's, and also to fulfill the requirements of the merchant shipping laws in Italy, the United States and Great Britain. In addition, she complies with all the requirements of the London Convention as regards subdivision, life-saving and other appliances.

The vessel has a straight stem and cruiser stern, two pole masts and two funnels.

Eight decks are fitted, with wide spaced pillars and girders, special attention being given to the superstructure, which is supported by specially designed external girders so that the interior decorations are not obstructed by pillars.

A cellular double bottom extends fore and aft, and is fitted for the carrying of both fresh and salt water, part of this space being reserved for boiler feed water and drinking water, and provision made for carrying ballast in the peaks and trimming tanks, the latter having large inlet valves in the ship's side for quick filling of these spaces.

A feature of the double bottom is that there are no bilges, the tank top plating being carried out to the skin of the vessel and drainage being arranged for by fitting wells.

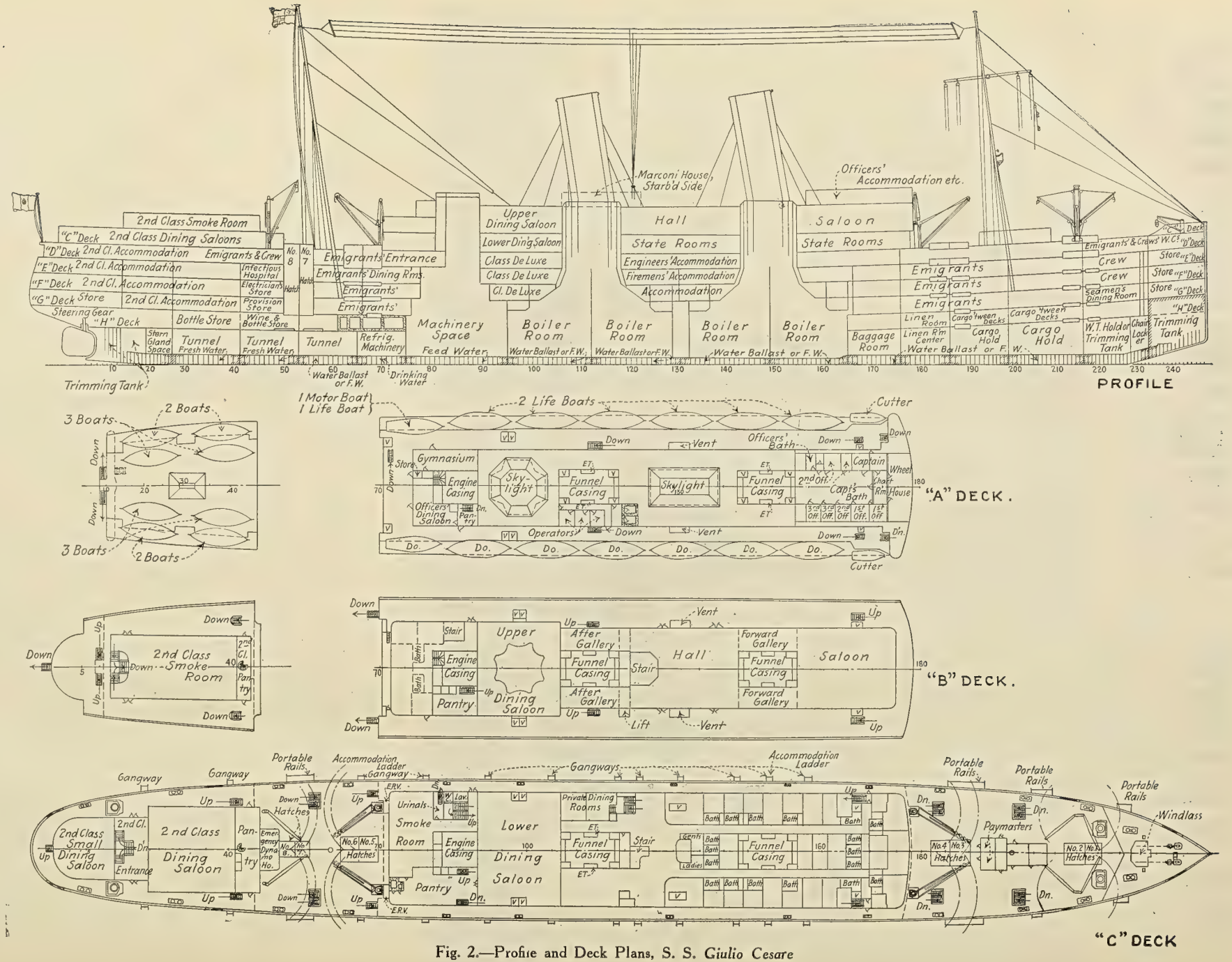


Fig. 2.—Profile and Deck Plans, S. S. *Giulio Cesare*

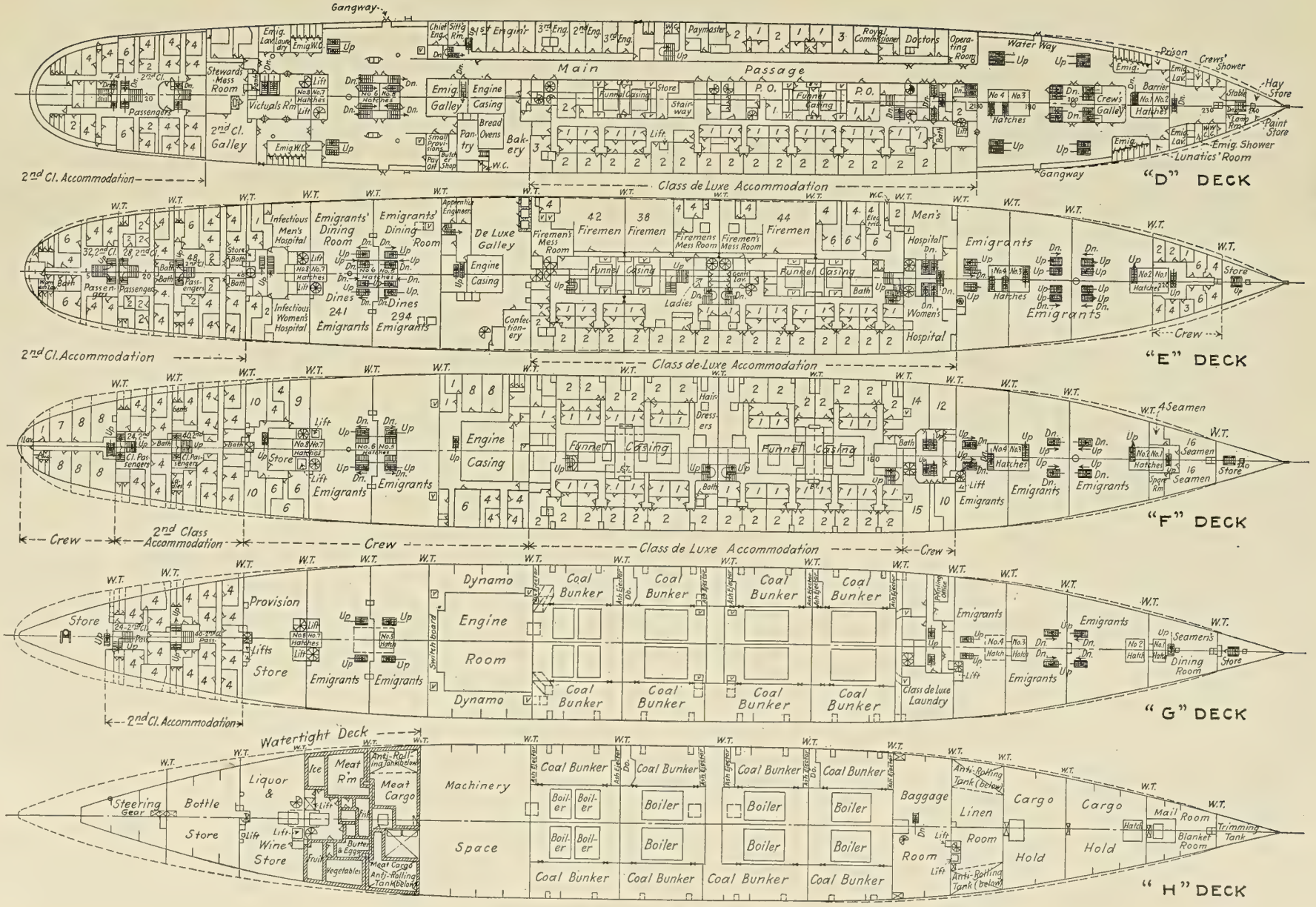


Fig. 3.—Deck Plans, S. S. *Giulio Cesare*

Passenger Liner Giulio Cesare

General Information

Service: Passenger—Genoa and Buenos Aires.

Builder: Messrs. Swan, Hunter & Wigham Richardson, Ltd., Wallsend-on-Tyne, England, Machinery by the Wallsend Shipway & Engineering Co., Ltd., Wallsend-on-Tyne, England.

Owner: Navigazione Generale Italiana, Genoa, Italy.

Characteristics

Length, overall .....632′ 11″
Length, B. P. .....601′ 5″
Breadth, molded ..... 76′ 0″
Breadth, extreme .....76′ 3½″
Depth, molded, to awning dk....50′ 2⅜″
Draft, loaded .....30′ 2″
Draft, light .....
Block coefficient .....
Midship section coefficient.....
Longitudinal coefficient .....
Speed, loaded, knots..... 19.5
Cruising radius, nautical miles.....
Framing .....Transverse
Class: Registro Nazionale Italiano, British Corporation and Lloyd's highest class

Tonnages

(In tons of 2,240 pounds)

*Weight of Hull.....
**Weight Propelling Machinery.....
Deadweight Capacity .....
Displacement .....

(In tons of 100 cubic feet)

Gross register 21,848
Net register 13,483

* Weight of Hull includes Hull Proper, Hull Fittings, Equipment, and Outfit.

** Weight of Propelling Machinery includes Engines, Boilers (Wet), Shafting, Propellers, and Machinery Space Auxiliaries.

Canal Ratings

(In tons of 100 cubic feet)

	Gross	Net
Suez		
Panama		

Equipment

2 Bower anchors, stockless.....146 cwts.
1 " " " .....124 "
1 Stream " ex. stock.....42¼ "
1 Kedge " " " ..... 22 "
Cable, 3⅜6″ stud chain.....330 fms.
Stream line 7″ steel wire.....150 "
Towline, 7½″ " " .....140 "
9″ Manila, (3) each.....120 "
8″ Manila, (3) each.....120 "

Rudder

Area .....
Dia. Stock .....19″
C. Press. abaft C. L. pintles .....

Complement

Officers 30
Crew and attendants 512
Total officers and crew..... 542
First-class passengers..... 243
Second-class passengers..... 306
Third-class passengers 1,824
Total passengers 2,373
Total complement 2,915

Handling Equipment

	No.	Type	Capacity	Length
Masts	2	Pole	....	....
Derrick posts	4	....	....	....
Booms	4	Hydraulic jib		....
Booms	6	....	....	....

Deck Machinery

Steering Gear, steam-driven type, telemotor control.
Windlass (1) .....14″ x 16″
Capstans (4) .....14″ x 12″
Winches .....electric for handling boats
.....

Life Saving Equipment

	No.	Type	Length
Lifeboats	30	decked	30′-0″
Motorboats	2	....	31′-4″
Cutters	2	....	20′-0″
Lifeboats	12	....	31′-4″
Lifeboats	4	....	31′-0″

Propelling Machinery

Boilers

Number 10
Type, multitubular, 6 double ended, 4 single ended.
Length.....D.E. 22′ 0″ S.E. 11′ 6″
Diameter .....15′ 6″
Furnaces, total 36
Fuel .....Coal
Draft .....Forced
Total heating surface, square feet.....
Total grate surface or furnace volume.....
.....
Superheat, degrees F.....200
Working pressure, lbs, per sq. in.....220
Normal fuel consumption:
Per day, tons .....
Per horsepower hour, pounds.....
Normal steam production:
Per hour per pound of fuel.....lbs.
Total per hour.....lbs.

Engines

Number .....4 sets
Type.....single reduction geared turbines
Size .....
Horsepower, shaft 21,900

Propellers

Number 4
Type .....
Weight .....
Diameter .....
Pitch .....
R. P. M. .....
Projected area .....
Developed area .....

Auxiliary Machinery

Machinery Space

Condensers designed to maintain, at full power, a vacuum of 28½ inches with a barometer of 30 inches.
Evaporators (2), capacity 72 tons of water per day each.
Distillers (2), capacity 72 tons of water per day each.
Filters .....Gravitation type
Feed water heater..surface multiflow type
Fuel oil heaters.....aux. condenser (1)
Pumps:
(2) Main circulating-centrifugal type driven by vertical, single cylinder, double acting engines.
Main air—Ind. vert. dual type driven by one steam cylinder.
(2 Pairs) Main feed—single cylinder, direct acting.
(4) Aux. feed—single cylinder, direct acting, vertical type.
(1) Aux. circulating—centrifugal type driven by a single cylinder engine.
(1) Aux. air—single cylinder, direct acting monotype
Lubricating oil—single cylinder, direct acting, vertical type.
Oil cooling—vert. duplex type.
(2) Distiller circulating—vert. duplex type.
Reserve fire—placed low and driven through gearing by an electric motor located above the load waterline.
Ash ejecting pumps, vert. duplex type.
Steam driven ash hoist in each stokehold.
Hydraulic plant.
(3) Ballast—vert. duplex type, capacity 200 tons water per hour.
Deck service—vert. duplex type.
Fresh water—vert. duplex type.
Drinking water—vert. duplex type.
Sanitary and fire—duplex type.

Refrigerating Machinery

CO_2 brine type plant, made by G. and E. Hall, Ltd., Dartford, Kent, England.

Electric Equipment

Generators..(4 sets) 180 k.w. each, located in engine room.
Radio .....Marconi set
Emergency....(1) oil driven generating set.

Holds

No.	Length	Hatches
1.....	40′-0″	
2.....	31′-0″	
.....		

Capacities

Cargo Space

Compartment	
.....	
.....	
.....	
.....	
.....	
.....	
.....	
.....	

Refrigerated Space

Compartment	Cu. Ft.
.....	
.....	

Bunkers

Compartment	Cu. Ft.	*Bbls.	*Tons
.....			
.....			
.....			
.....			
.....			
.....			

*....cu. ft. per ton;.....gals, per bbl.

Tanks

	Cu. Ft.	Tons F. W.	Tons S. W.
(4) drinking water			
(2) fresh water			
(1) salt water			
(4) boiler feed			
(24) fresh or salt water			
(2) anti-rolling tanks			
(2) trimming tanks			
Fore peak			
After peak			
.....			
.....			
Total			

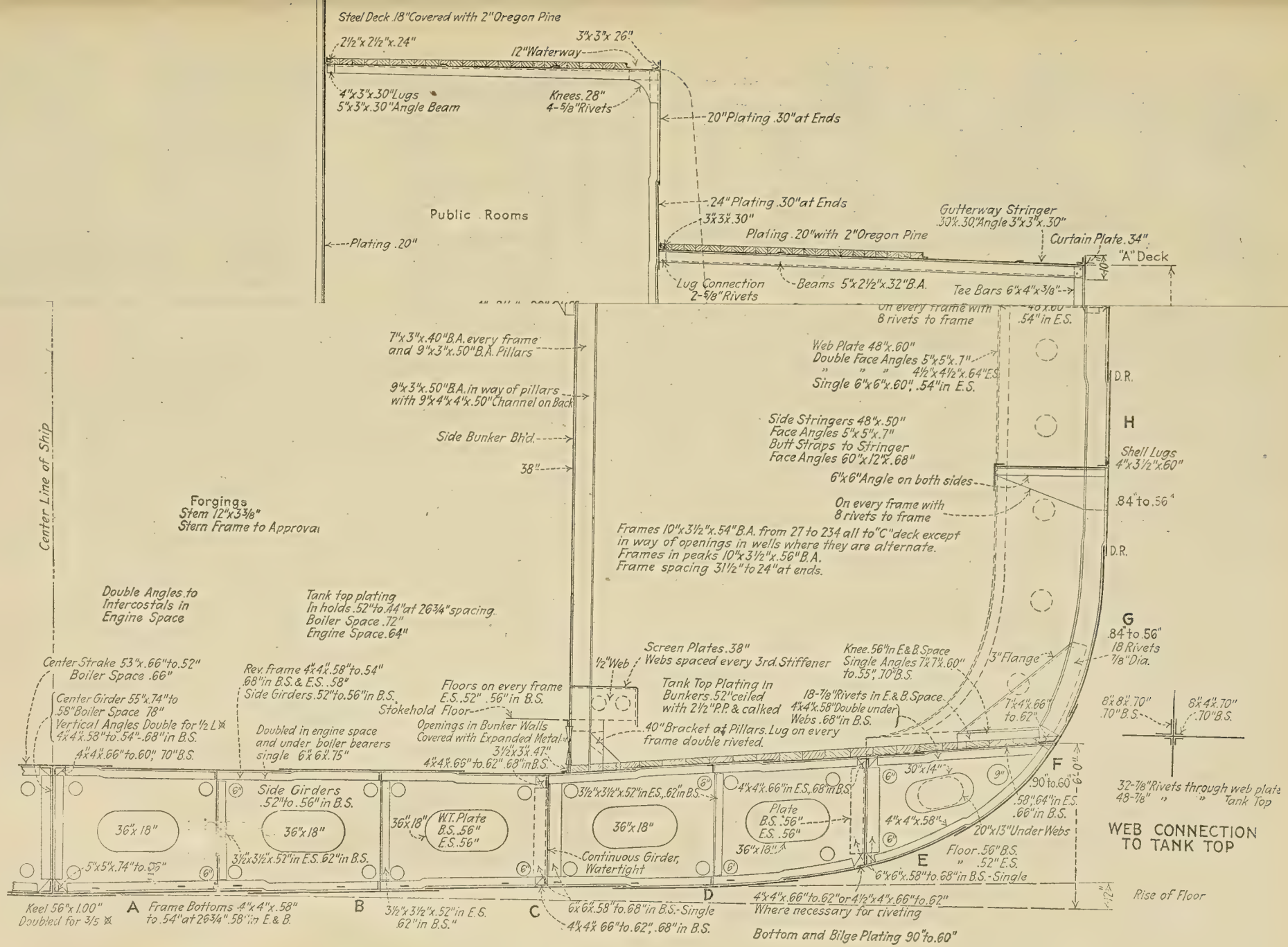
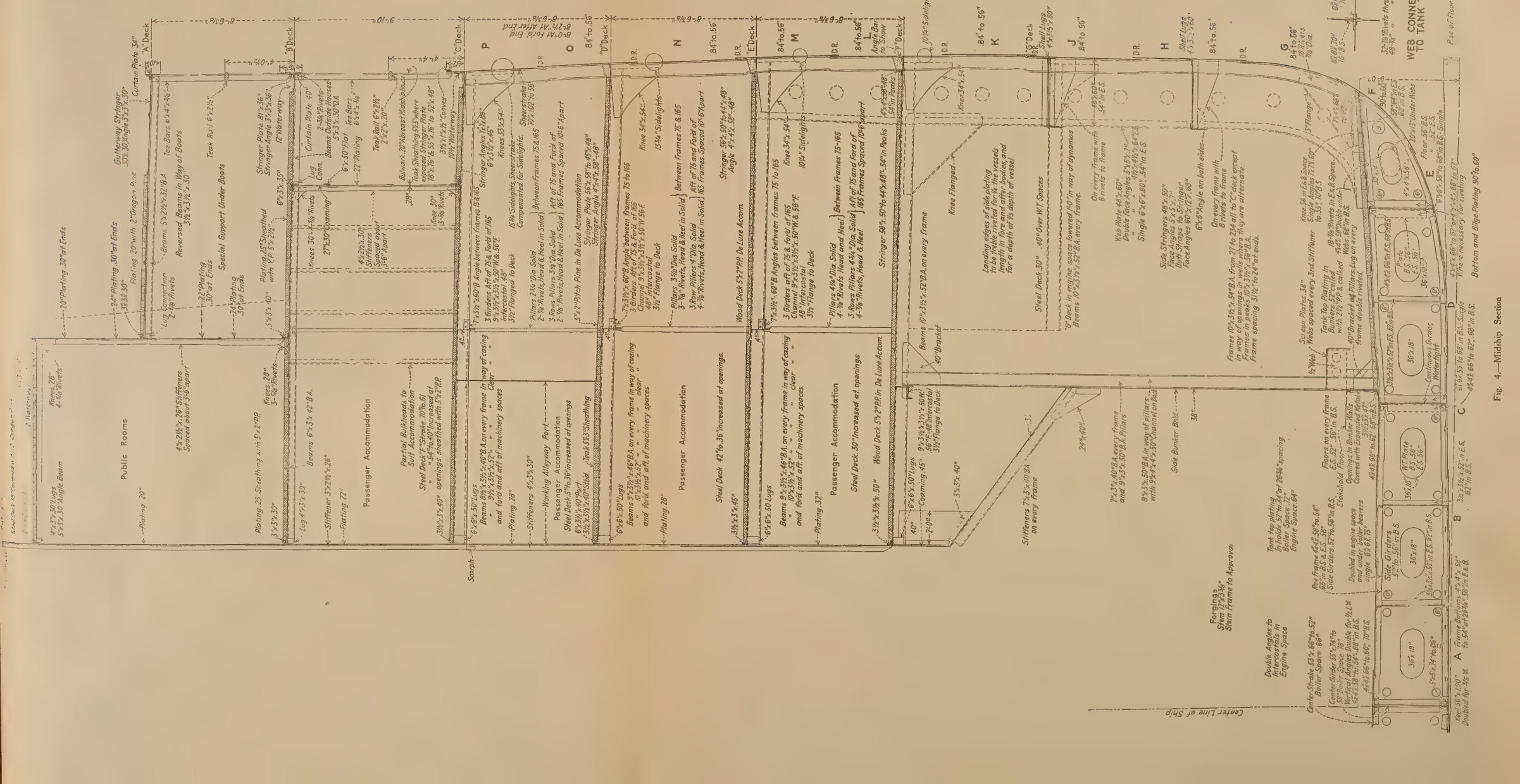
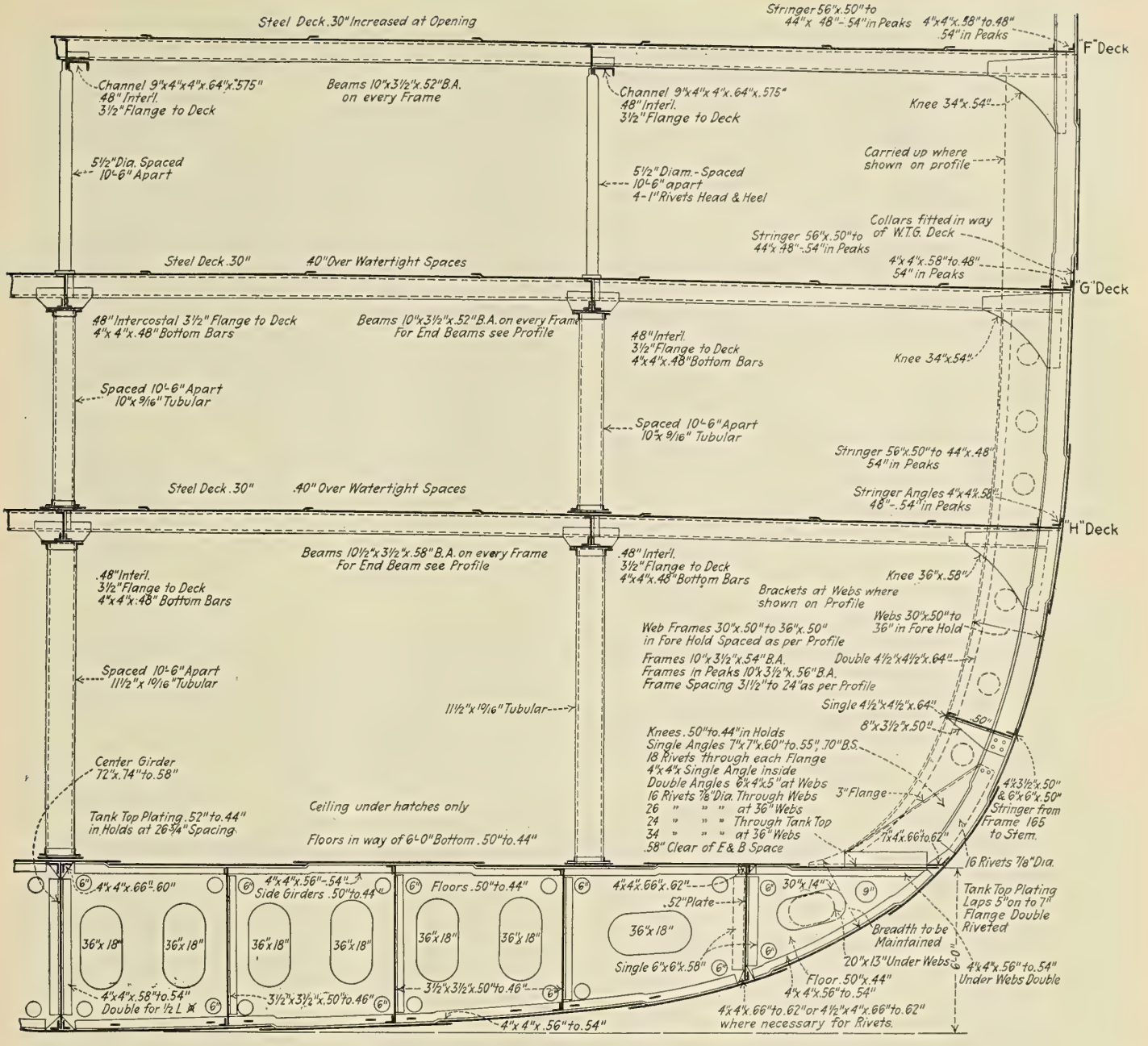

Steel Deck .18" Covered with 2" Oregon Pine
2½"x 2½"x .24"
3"x 3"x .26"
12" Waterway
4"x 3"x .30" Lugs
5"x 3"x .30" Angle Beam
Knees .28"
4-⅝" Rivets
20" Plating .30" at Ends
24" Plating .30" at Ends
Public Rooms
Plating .20"
3"x 3"x .30"
Gutterway Stringer .30"x .30" Angle 3"x 3"x .30"
Plating .20" with 2" Oregon Pine
Curtain Plate .34"
"A" Deck
Lug Connection 2-⅝" Rivets
Beams 5"x 2½"x .32" B.A.
Tee Bars 6"x 4"x ⅜"
on every frame with 8 rivets to frame
.54" in E.S.
7"x 3"x .40" B.A. every frame and 9"x 3"x .50" B.A. Pillars
Web Plate 48"x .60"
Double Face Angles 5"x 5"x .7"
" " " 4½"x 4½"x .64" E.S.
Single 6"x 6"x .60", .54" in E.S.
D.R.
H
9"x 3"x .50" B.A. in way of pillars with 9"x 4"x 4"x .50" Channel on Back
Side Bunker Bhd.
38"
Side Stringers 48"x .50"
Face Angles 5"x 5"x .7"
Butt Straps to Stringer
Face Angles 60"x 12"x .68"
Shell Lugs 4"x 3½"x .60"
6"x 6" Angle on both sides
On every frame with 8 rivets to frame
.84" to .56"
Center Line of Ship
Forgings
Stem 12"x 33⅛"
Stern Frame to Approval
Frames 10"x 3½"x .54" B.A. from 27 to 234 all to "C" deck except in way of openings in wells where they are alternate.
Frames in peaks 10"x 3½"x .56" B.A.
Frame spacing 31½" to 24" at ends.
D.R.
Double Angles to Intercostals in Engine Space
Tank top plating In holds .52" to .44" at 26¾" spacing.
Boiler Space .72"
Engine Space .64"
G
.84" to .56"
18 Rivets
⅞" Dia.
Screen Plates .38"
Webs spaced every 3rd Stiffener
Knee .56" in E&B Space
Single Angles 7"x 7"x .60" to .55", .70" B.S.
3" Flange
½" Web
Center Strake 53"x .66" to .52"
Boiler Space .66"
Rev. frame 4"x 4"x .58" to .54"
.68" in B.S. & E.S. .58"
Side Girders .52" to .56" in B.S.
Floors on every frame E.S. .52" .56" in B.S.
Stokehold Floor
Tank Top Plating In Bunkers .52" ceiled with 2½" P.P. & calked
18-⅞" Rivets in E.&B. Space
4"x 4"x .58" Double under Webs .68" in B.S.
7"x 4"x .66" to .62"
8"x 8"x .70"
.70" B.S.
8"x 4"x .70"
.70" B.S.
Center Girder 55"x .74" to .55" Boiler Space .78"
Vertical Angles Double for ½ L
4"x 4"x .58" to .54" - .68" in B.S.
4"x 4"x .66" to .60", .70" B.S.
Doubled in engine space and under boiler bearers single 6"x 6"x .75"
Openings in Bunker Walls Covered with Expanded Metal
3½"x 3"x .47"
4"x 4"x .66" to .62" .68" in B.S.
40" Bracket at Pillars. Lug on every frame double riveted.
F
90" to 60"
30"x 14"
9"
6"
Side Girders .52" to .56" in B.S.
36"x 18"
36"x 18"
36"x 18"
W.T. Plate B.S. .56" E.S. .56"
3½"x 3½"x .52" in E.S. .62" in B.S.
3½"x 3½"x .52" in E.S. .62" in B.S.
4"x 4"x .66" in E.S. .68" in B.S.
Plate B.S. .56" E.S. .56"
36"x 18"
4"x 4"x .58"
.58" .64" in E.S.
.66" in B.S.
20"x 13" Under Webs
Continuous Girder, Watertight
Floor .56" B.S.
" .52" E.S.
E
6"x 6"x .58" to .68" in B.S. - Single
5"x 5"x .74" to .55"
32-⅞" Rivets through web plate
48-⅞" " " Tank Top
WEB CONNECTION TO TANK TOP
Keel 56"x 1.00"
Doubled for 3/5
A
Frame Bottoms 4"x 4"x .58" to .54" at 26¾". 58" in E.& B.
B
C
D
6"x 6"x .58" to .68" in B.S. - Single
4"x 4"x .66" to .62", .68" in B.S.
4"x 4"x .66" to .62" or 4½"x 4"x .66" to .62" Where necessary for riveting
Bottom and Bilge Plating 90" to 60"
Rise of Floor

Fig. 4.—Midship Section

PASSENGER LINER GIULIO CESARE


A Deck
B Deck
C Deck
D Deck
E Deck
F Deck
Public Rooms
Passenger Accommodation
Special Support Under Boats
Reversed Beams in Way of Boats
Gutterway Stringer
Curtain Plate 32"
Curtain Plate 40"
Teak Rail 6"x2½"
Teak Sheathing 5¾" where exposed, Stringer Plate
Bulwark 20" Abreast Midship Hold
Steel Deck 30" Over W.T. Spaces
"G" Deck in engine space lowered 140" in way of dynamos
Beams 10"x3½"x.52" B.A. every frame.
Landing edges of side plating to be treble riveted for ¼ the vessels length in fore and after bodies, and for a depth of ⅓ depth of vessel
Knee Flanged
Knee 34"x.54"
Beams 10"x3½"x.52" B.A. every Frame
Bracket
Stringer 56"x.50" to 44"x.48" Angle 4"x4"x.58"-.48"
Wood Deck 5"x2" P.P. De Luxe Accom.
Steel Deck. 30" increased at openings
Steel Deck 42" to 36" increased at openings.
Steel Deck. 30" increased at openings
Steel Deck 5"x2" P.P. in De Luxe Accom.
Stringer 56"x.50" to 44"x.48" 54" in Peaks
Between Frames 75 to 165
Between Frames 75 & 165
Between Frames 75 to 165
Between Frames 75 to 165
Aft of 75 and Ford of 165 Frames Spaced 10⅝" Apart
Aft of 75 & Ford of 165 Frames Spaced 10⅝" Apart
Aft of 75 and Ford of 165 Frames Spaced 10⅝" Apart
Aft of 75 & Ford of 165 Frames Spaced 10⅝" Apart
Between Frames 75 & 165
Between Frames 15 & 165
Between Frames 15 to 165
Between Frames 15 to 165
Between Frames 15 to


Steel Deck .30" Increased at Opening
Stringer 56"x.50" to 44"x 48"-.54" in Peaks
4"x4"x.58" to.48" .54" in Peaks
"F" Deck
Channel 9"x4"x4"x.64"x.575" 48" Interl. 3½" Flange to Deck
Beams 10"x3½"x.52" B.A. on every Frame
Channel 9"x4"x4"x.64"x.575" 48" Interl. 3½" Flange to Deck
Knee 34"x.54"
5½" Dia. Spaced 10'-6" Apart
5½" Diam.-Spaced 10'-6" apart 4-1" Rivets Head & Heel
Carried up where shown on profile
Collars fitted in way of W.T.G. Deck
Stringer 56"x.50" to 44"x.48"-.54" in Peaks
Steel Deck .30"
40" Over Watertight Spaces
4"x4"x.58" to.48" .54" in Peaks
"G" Deck
48" Intercostal 3½" Flange to Deck 4"x4"x.48" Bottom Bars
Beams 10"x3½"x.52" B.A. on every Frame For End Beams see Profile
48" Interl. 3½" Flange to Deck 4"x4"x.48" Bottom Bars
Knee 34"x.54"
Spaced 10'-6" Apart 10"x 9/16" Tubular
Spaced 10'-6" Apart 10"x 9/16" Tubular
Stringer 56"x.50" to 44"x.48" .54" in Peaks
Steel Deck .30"
.40" Over Watertight Spaces
Stringer Angles 4"x4"x.58" 48"-.54" in Peaks
"H" Deck
Beams 10½"x3½"x.58" B.A. on every Frame For End Beam see Profile
.48" Interl. 3½" Flange to Deck 4"x4"x.48" Bottom Bars
.48" Interl. 3½" Flange to Deck 4"x4"x.48" Bottom Bars
Knee 36"x.58"
Brackets at Webs where shown on Profile
Webs 30"x.50" to 36" in Fore Hold
Web Frames 30"x.50" to 36"x.50" in Fore Hold Spaced as per Profile
Frames 10"x3½"x.54" B.A.
Frames in Peaks 10"x3½"x.56" B.A.
Frame Spacing 31½" to 24" as per Profile
Double 4½"x4½"x.64"
Spaced 10'-6" Apart 11½"x 19/16" Tubular
Single 4½"x4½"x.64"
11½"x 19/16" Tubular
8"x3½"x.50"
.50"
Knees .50" to.44" in Holds
Single Angles 7"x7"x.60" to.55", .70" B.S.
18 Rivets through each Flange
4"x4" Single Angle inside
Double Angles 6"x4"x.5" at Webs
16 Rivets ⅞" Dia. Through Webs
26 " " " at 36" Webs
24 " " " Through Tank Top
34 " " " at 36" Webs
.58" Clear of E & B Space
3" Flange
4"x3½"x.50" & 6"x6"x.50" Stringer from Frame 165 to Stem.
Center Girder 72"x.74" to.58"
Tank Top Plating .52" to.44" in Holds at 26¾" Spacing
Ceiling under hatches only
Floors in way of 6'-0" Bottom .50" to.44"
7"x4"x.66" to.62"
16 Rivets ⅞" Dia.
Tank Top Plating Laps 5" on 7" Flange Double Riveted
4"x4"x.66"-.60"
4"x4"x.56"-.54" Side Girders .50" to.44"
Floors .50" to.44"
4"x4"x.66"x.62"
.52" Plate
30"x.14"
9"
36"x18"
Breadth to be Maintained
Single 6"x6"x.58"
20"x13" Under Webs
4"x4"x.56" to.54" Under Webs Double
Floor .50" x.44"
4"x4"x.58" to.54" Double for ½ L
3½"x3½"x.50" to.46"
3½"x3½"x.50" to.46"
4"x4"x.56" to.54"
4"x4"x.66" to.62" or 4½"x4"x.66" to.62" where necessary for Rivets.

SECTION IN WAY OF HOLDS

Fig. 5

Two anti-rolling tanks are built into the ship's structure and the usual bilge keels are dispensed with.

The bulkheads between the engine and boiler rooms are intact, but access is obtained to the tunnels and machinery space by watertight doors, similar doors being also fitted in certain midship watertight bulkheads on *E* deck dividing the accommodation spaces.

Fire resisting bulkheads and doors are fitted in the central part of the vessel on the upper decks to prevent the spread of fire in the event of an outbreak.

Accommodations.

Accommodations are provided for 243 *de luxe* passengers in double and single berth cabins, private bath rooms with tile floors and walls being fitted one for every three passengers. A prominent feature of the first-class accommodations is the spacious and lofty superstructure comprising the entrance hall, galleries, library, saloon, etc. Special suite rooms are also arranged for, the entire accommodations being fitted out in a luxurious manner.

The second-class passenger accummodations provide for 306 to be berthed aft, generally in four-berth rooms, provision also being made for two dining rooms and a smoking room.

Accommodations for carrying 1,824 immigrants are provided in the 'tween decks forward and aft of the machinery space.

The captain, deck officers and wireless operators are accommodated in deckhouses above the midship superstructure, in which is also located the *de luxe* gymnasium. The engineers are berthed on the port side of the vessel on the awning deck in way of the engine room. The crew and attendants are berthed in various parts of the vessel.

Roomy promenade spaces are provided, the forward portion of that allotted to the *de luxe* passengers being inclosed by large windows of the railway carriage type.

Propelling Machinery

The propelling machinery and boilers were built and installed by the Wallsend Slipway & Engineering Company,

Ltd., Wallsend-on-Tyne. Four screws are provided, the power for driving which consists of four sets of single reduction gear turbines. The turbine sets consist of high and low pressure units working in series, which arrangement applies both to the ahead and astern going direction of rotation. The design of the turbines adopted is one having impulse wheel stages for all turbines, the high pressure ahead turbine containing 11 wheels in which the first wheel has two rows of blades, while the remaining wheels each have one row of blades. The low pressure ahead turbine contains 11 wheels, having a single row of blades to each wheel. The astern going high and low pressure turbines are each provided with one wheel having multiple rows of blades.

Arrangements are made whereby the high pressure and low pressure turbines can be operated independently should a breakdown occur to either. The admission of steam to the high pressure ahead turbine is under effective control by arranging the first stage nozzles in groups and providing each of these groups with its own controlling valve. Economy in consumption of steam is thus obtained as the number of nozzles open at one time can be regulated and a full pressure head of steam kept under a wide variation in load.

Six double ended and four single ended boilers of the ordinary multitubular type are provided and arranged in four watertight compartments with the single ended boilers placed aft. The boiler room arrangements are in accordance with the requirements of Howden's forced draft.

Superheating appliances are fitted to provide for a superheat of 200 degrees Fahrenheit at the turbine maneuvering valve.

The stacks are oval shape with outer casings carried the full height, the total height being 126 feet above the furnaces.

Air supply for the forced draft system is provided by 8 single ended type motor driven fans and suitable fan rooms are provided immediately above the stokeholds, the fans delivering the air down to the air heating boxes by means of trunks. Arrangements are made so that the operation of the fans can be controlled both from the fan room and the stokehold floor.

Trials

The sea trials of this vessel have just been completed and a satisfactory feature of the ship was the almost complete absence of vibration when running at top speed. A 24-hour trial at 19½ knots was run to test the vessel's speed, after which another trial of 24 hours' duration was run at a speed of 18½ knots to determine the coal consumption. Both trials passed off very successfully and to the complete satisfaction of the owners and builders.

Passenger and Cargo Vessel San Lorenzo

Reconditioned Vessel Placed in the New York to Porto Rico Service by the New York & Porto Rico Steamship Company

WHEN the steamship *San Lorenzo* sailed for Porto Rico on March 12, the New York & Porto Rico Steamship Company had added to its high class passenger service what was virtually a new vessel. In her original design the *San Lorenzo,* ex-*Brazos,* was well known in the New York and Porto Rico trade. Last fall her owners turned her over to the Robins Dry Dock & Repair Company, Erie Basin, Brooklyn, N. Y., where from plans and specifications prepared by Theodore E. Ferris, naval architect, along lines laid down by Franklin D. Mooney, president of the New York & Porto Rico Steamship Company, the vessel has been rebuilt and refitted, the work having been carried through to completion under the supervision of Mr. Ferris.

The reconditioning of this vessel has greatly increased her passenger accommodations, there being more staterooms, and by clever designing more space was made available for the building in of suites de luxe. The new arrangement finds the officers' quarters on the upper deck, a plan which has proved successful on other passenger liners.

The *San Lorenzo* is a hurricane deck type ship having main, lower and orlop decks. She carries a double bottom under the boiler space, and built-in fresh water tanks. There are five transverse bulkheads.

The principal changes in the vessel as a result of reconditioning are as follows:

Hull

The break in the deck house aft has been eliminated and the boat and promenade deck constructed to extend from the bridge all the way aft. New fresh water and fuel oil

Fig. 1.—S. S. *San Lorenzo,* Reconditioned for New York and Porto Rico Service

Fig. 2.—Interior Views of S. S. *San Lorenzo:* (1) New Companionway, (2) Dining Saloon, (3) Dancing Deck, (4) Sun Parlor, (5) Reading and Writing Room, (6) Smoking Room

Passenger and Cargo Vessel San Lorenzo

General Information

Service: Freight and passenger, New York to Porto Rico.

Builder: Newport News S. B. & D. D. Co., Newport News, Virginia.

Designer: Theo. E. Ferris, 30 Church St., New York.

Owner: New York & Porto Rico Steamship Co., New York.

Characteristics

Length, overall	416′-0″
Length, B. P.	400′-0″
Breadth, molded	54′-0″
Depth, molded to hurricane deck	37′0″
Draft, loaded	24′-0″
Draft, light	12′-10″
Block coefficient	0.684
Midship section coefficient	0.967
Longitudinal coefficient	0.706
Speed, loaded, knots	14
Cruising Radius, nautical miles	5,150
Framing	Transverse
Class	

Tonnages

(In tons of 2,240 pounds)

*Weight of Hull	3,650
**Weight Propelling Machinery	1,250
Deadweight Capacity	5,300
Displacement	10,200

(In tons of 100 cubic feet)

Gross register	6,605
Net register	4,035

*Weight of Hull includes Hull Proper, Hull Fittings, Equipment, and Outfit.

** Weight of Propelling Machinery includes Engines, Boilers (Wet), Shafting, Propellers, and Machinery Space Auxiliaries.

Canal Ratings

(In tons of 100 cubic feet)

	Gross	Net
Suez		
Panama		

Equipment

Anchors

Chain

Rudder

Area

Dia. Stock ..... 11″

C. Press. abaft C. L. pintles

Complement

Deck officers	4
Deck crew	18
Engineer officers	4
Engineer crew	27
Purser's and steward's department	81
Total officers and crew	134
First-class passengers	216
Second-class passengers	
Third class passengers	
Total passengers	216
Total complement	350

Handling Equipment

	No.	Type	Capacity	Length
Masts (1 dummy)	2	Pole	....	68 ft. above deck
Derrick	1	Steel	30 Tons	51 ft.
Booms	4	Wood	8 Tons	2-50 ft. 2-42 ft.

Deck Machinery

Steering Gear

Windlass

Capstans

Winches ..... (4) 8¼″ x 10″ single gear
(5) 8″ x 8″
(1) 10″ x 12″

Life Saving Equipment

	No	Capacity	Length
Lifeboats	12	35 persons	24′-0″
Lifeboats	2	30 persons	24′-0″

Propelling Machinery

Boilers

Number	6
Type	single-ended Scotch
Length, over heads	12′-4 3/16″
Diameter	15′-8″
Furnaces, each boiler	4
Fuel	Oil
Draft	Forced
Total heating surface, square feet	17,478
Total furnace volume, cu. ft.	439.8
Superheat, degrees F	
Working pressure, lbs. per sq. in.	215
Normal fuel consumption:	
Per day, tons	83.5
Per horsepower hour, pounds	1.2
Normal steam production:	
Per hour per pound of fuel	lbs.
Total per hour	lbs.

Engines

Number	2
Type	quad. exp. recip.
Size	23 5/16″ x 48 7/16″ x 33¾″ x 68″
Horsepower	6,500

Propellers

Number	2
Type	3 bladed—built up
Weight	
Diameter	15′-0″
Pitch	19′-0″
R. P. M.	70
Projected area, square feet	51.0
Developed area, square feet	63.3

Auxiliary Machinery

Machinery Space

Main Condensers (2) each 5,025 sq. ft. cooling surface

Aux. Condenser (1) 1,000 sq. ft. cooling surface

Evaporators

Distiller

Filters (1) feed and filter tank. 2,400 gals.

Feed water heater (1) Griscom-Russell No. 30.

Fuel oil heaters 3

Pumps

(1) Main air, vert. twin beam. 12 x 28 x 18.
(1) Main circulating, size 15″.
(1) Main feed, vert. simplex, 14 x 10 x 24.
(1) Aux. feed, vert. simplex, 14 x 10 x 24.
(1) Fire, bilge and general service, vert. duplex, 12 x 8½ x 12.
(1) Aux. condenser circulating, vert. simplex, 12 x 14 x 12.
(1) Sanitary, vert. duplex, 7½ x 9 x 10.
(1) Freshwater, vert. duplex, 7½ x 5 x 6.
(2) Fuel oil, vert. duplex, 6 x 4 x 6.
(1) Oil transfer, vert. duplex, 7½ x 6 x 10.

Refrigerating Machinery

(3) 4 ton ice machines—Brunswick.
(1) con. circ. pump, vert. duplex, 7½ x 5 x 6.
Scuttle butt (1) 90 gals.
(1) Circ. pump, vert. duplex 4½ x 3¾ x 4.

Electric Equipment

Generators ..... (3) 30 kilowatts
Radio
Emergency

Holds

No.	Length	Hatches
1	65′-0″	10′-10″ x 10′-0″
2	56′-4″	8′-8″ x 12′-0″ 13′-0″ x 18′-0″
3	75′-10″	13′-0″ x 18′-0″ 10′-10″ x 12′-0″

Capacities

Cargo Space

Compartment	Bales Cu. Ft.
No. 1 hold	14,150
No. 2 hold	48,000
No. 3 upper hold	29,700
No. 3 lower hold (P & S)	9,500
Orlop 'tween decks (for'd.)	16,750
No. 1 lower 'tween decks	19,000
No. 2 lower 'tween decks	32,950
No. 3 lower 'tween decks	40,800
In way boiler casing (P & S)	9,600
In way engine casing (P & S)	4,700
Main 'tween dks. No. 1 cargo space	13,500
Main 'tween dks. No. 2 cargo space	6,750
Main 'tween dks. No. 3 cargo space	5,450
Main 'tween dks. No. 4 cargo space	26,900
Total	277,750

Refrigerated Space

Compartment	Cu. Ft.
Cargo cold storage (port)	2,000
Cargo cold storage (starb'd)	850
Cargo cold storage (starb'd	850
Meat	1,050
Fruit	820
Vegetables	630
Total	6,200

Bunkers

Compartment	Cu. Ft.	*Bbls.	*Tons
Double B.T.M. Tank (P)	4,950	880	134
" " " (S)	4,950	880	134
Deep Tank (P)	9,500	1,696	257
" " (S)	9,200	1,642	249
Wing Tank (P)	9,390	1,673	254
" " (S)	9,390	1,673	254
Total	47,380	8,444	1,282

2 percent deduction allowed for expansion.
* 36.97 cu. ft. per ton; ..... 42 gals. per bbl.
Beame = 14

Tanks

Compartment	Cu. Ft.	Tons F. W.	Tons S. W.
Frs. 124-130 Port	4,460	124	
Frs. 124-130 Starb'd	4,460	124	
Frs. 124-130 C. L.	970	27	
Frs. 154-160	1,405	39	
Frs. 160-165	1,320	37	
Fore Peak	2,700	75	77
Aft Peak	9,400	261	269
Total	24,715	687	346

tanks to suit the new oil burning arrangement have been built into the hull and the entire vessel scaled and surveyed, such portions of the hull as necessary being renewed or repaired.

ENGINES

The engines have been thoroughly overhauled and brought into first class working condition.

BOILERS

Six new boilers built by the Newport News Shipbuilding & Dry Dock Company, Newport News, Va., are installed in the vessel to take the place of the old boilers which were removed. The new boilers are fitted for burning oil, the oil burning installation being of the type manufactured by the White Fuel Oil Engineering Company. Fuel oil is carried in the double bottom tanks which are fitted with the necessary heating coils and grids.

In connection with the new fuel system, all equipment for the use of coal, such as ash ejectors, ash hoists and other appliances of this kind have been removed. The coal ports on the port and starboard sides of the lower deck have been permanently closed and a new boiler hatch built to suit the latest arrangement, the top or fidley being fitted with gratings and hinge covers. The new fireroom is served by four ventilators 48 inches in diameter operated with turning gear from the fireroom grating or lower deck level.

PIPING

In order to supply the new arrangement of living accommodations, a completely new system of water piping was necessary throughout the ship. This included both fresh and salt water as well as sanitary piping for the toilets.

To make this vessel comfortable in cold weather, the steam heating system was entirely re-piped, using as many of the old radiators as possible after having thoroughly cleaned and put them in first class condition.

ELECTRICAL WORK

An entirely new and complete installation of electric lighting was fitted throughout the vessel. Annunciator and call systems were also installed in all quarters.

ACCOMMODATIONS

A Deck.—With the new arrangement, the boat, or *A* deck as it is now termed, will have the accommodations for the deck and engineer officers, engine crew, petty officers, cooks, pantry men, etc., located at the forward end. Aft of these is located a sun parlor and smoking room both of which are luxuriously fitted out. A refreshment room and barber shop are located abreast the smoking room. Further aft is a shelter deck enclosure which with its wide windows and doors will be a popular resort in rainy weather. The wireless room is in a separate house near the stern, being located in the center of what is termed the dancing deck, an open space for the amusement of the passengers.

The lifeboats are also located on this deck and are strung out amidships, there being fourteen lifeboats provided, each capable of holding thirty-five persons.

Promenade or B Deck.—The promenade or B deck begins at the bridge the same as the deck above. The lounge and music rooms are located at the forward end and are fitted with large windows which provide a pleasing view ahead. Aft of that room are four suite staterooms consisting of a stateroom and bath. Sleeping accommodations in the form of two separate beds with a folding berth above provide ample comfort for a small family.

These are followed by two-berth staterooms at the port and starboard sides of the ship which extend as far aft as the social hall, which is built around the main stairway leading from the decks below.

Aft of the social hall are eight suite staterooms and from this point on, two-berth staterooms are carried to the stern, sufficient space being left at the extreme stern to provide open deck space for walking from one side of the ship to the other. A promenade is afforded on both sides of the vessel between the deck house and the ship's side for the full length of the deck.

Hurricane or C Deck.—The hurricane or *C* deck has a small steel deck house forward containing the seamen's quarters and boatswain. There is an open space between the forward house and main house on this deck which comes in line with the bridge and decks overhead. On the forward end of the main deck house is a dining saloon which is arranged to give the maximum accommodation and comfort in order to overcome the set and stiff appearance so often seen in dining rooms in even the largest steamers afloat. Some of the larger tables in the central part of the room will seat eight people and others will accommodate six at one time. For smaller families tables seating three will be found, while tables for two are located against the bulkheads. The main pantry is directly aft of the dining room and is served by a dumbwaiter from the galley on the deck below, this same dumbwaiter also being used to furnish food for the officers' mess above.

Two-berth staterooms are built on both the port and starboard sides from here aft to the social hall, located on this deck amidships directly under the social hall on the deck above. The chief steward has a stateroom forward near the main pantry on the starboard side and the purser's room is on the same side, but further aft, being opposite the main stairway to the deck above.

The inside finish of all the quarters was planned to be neat, artistic and in good taste with the surroundings. Mahogany finish has been adopted in many places and fumed oak in the smoking room. Leaded glass doors or screens of appropriate design lend attractiveness to the principal rooms and a white enamel finish tinted with gold stripe marking adds to the attractiveness of the public rooms.

Launching of 33,000-Ton Battleship *Colorado* at Yards of New York Shipbuilding Corporation. Vessel Will Be Driven at 21 Knots by Westinghouse Electric Propelling Equipment of 32,000 Horsepower

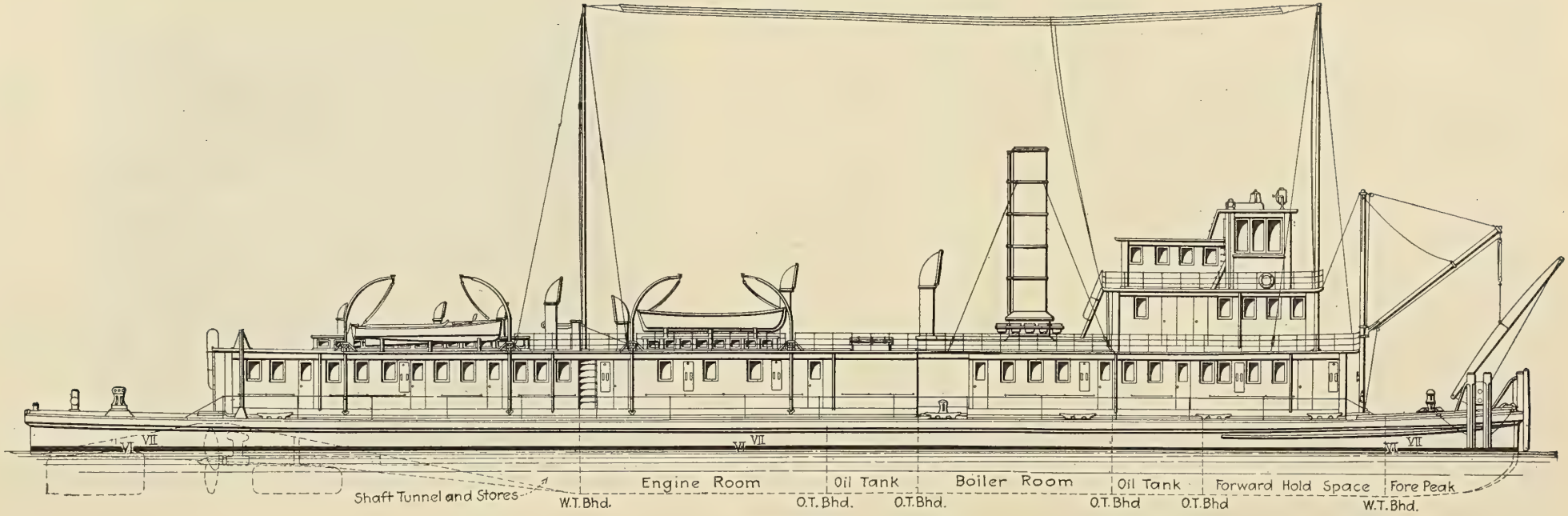


Fig. 1.—Outboard Profile of River Towboat *Natchez*

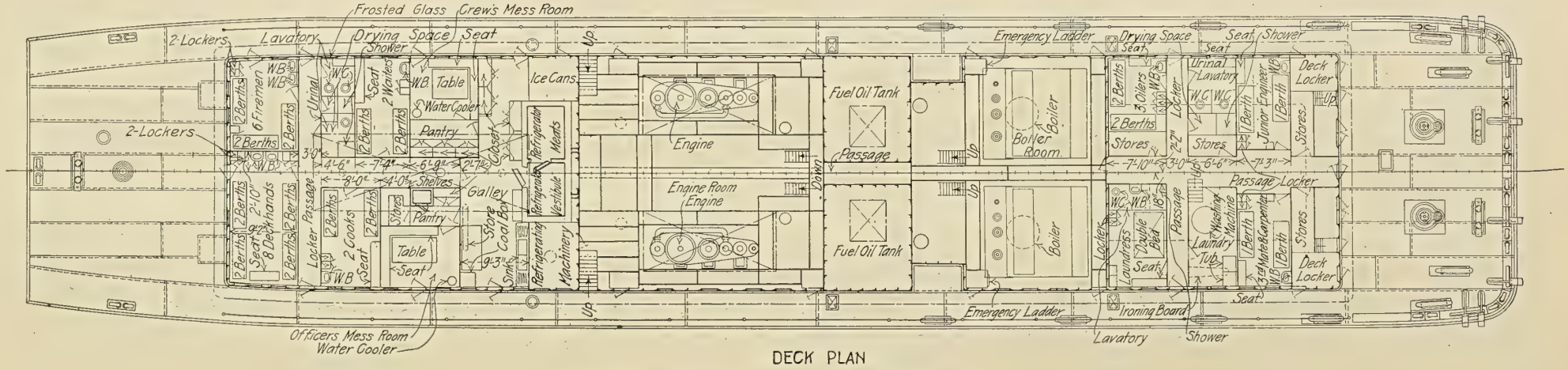


Fig. 2.—Main Deck Plan of River Towboat *Natchez*

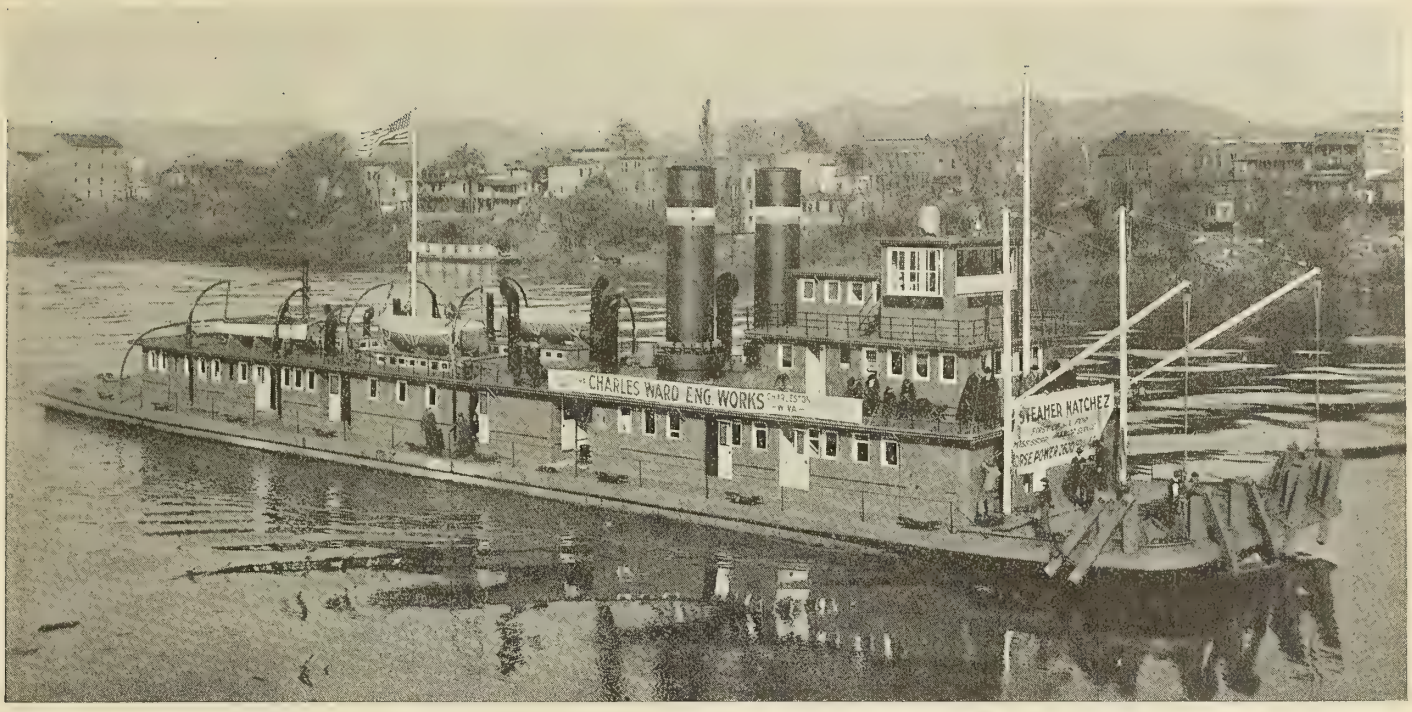


Fig. 3.—Twin-Screw Tunnel-Stern Towboat *Natchez*

Mississippi-Warrior River Towboats

Description of the Natchez, the Most Powerful River Towboat Ever Built—The First of Six to be Operated by the Government

THE steamer *Natchez,* the first of a fleet of six powerful twin screw tunnel towboats, designed by Cox and Stevens, naval architects, New York, for service on the Mississippi River was recently completed and delivered to the Government by The Charles Ward Engineering Works, Charleston, W. Va.

These boats are the most powerful river towboats that have ever been built in this country or abroad. They are to be operated by the War Department, under direction of the Chief of Inland and Coastwise Waterways Service, as the Federal Barge Line, of which Mr. Theodore Brent is Federal manager at New Orleans and Colonel G. E. Humphrey manager at St. Louis.

Under normal conditions these boats are to handle from five to six steel barges; each barge to be 45 feet wide by 230 feet long with a draft of from 7 feet to 10 feet, depending on the stage of water in the rivers, and having a maximum carrying capacity of about 2,000 tons.

The *Vicksburg,* a sister ship of the *Natchez,* is nearing completion at the plant of The Charles Ward Engineering Works, and the Marietta Manufacturing Company, Point Pleasant, W. Va., is building the other four vessels, two of which are nearly finished.

All the vessels are duplicates and of the following dimensions:

Length	200 feet
Beam	40 feet
Depth	10 feet
Draft	6½ to 7 feet

General Arrangement

The vessels are equipped with every modern convenience for efficient operation and the comfort of the crew, including steam heat, hot and cold water, numerous shower baths, electric fans, a laundry with electric washing machine and, to provide constant communication with the terminals at New Orleans, a complete wireless system will be installed, the masts for which are already in place.

Figs. 2 and 3 show the general arrangement of the quarters and machinery.

Hull

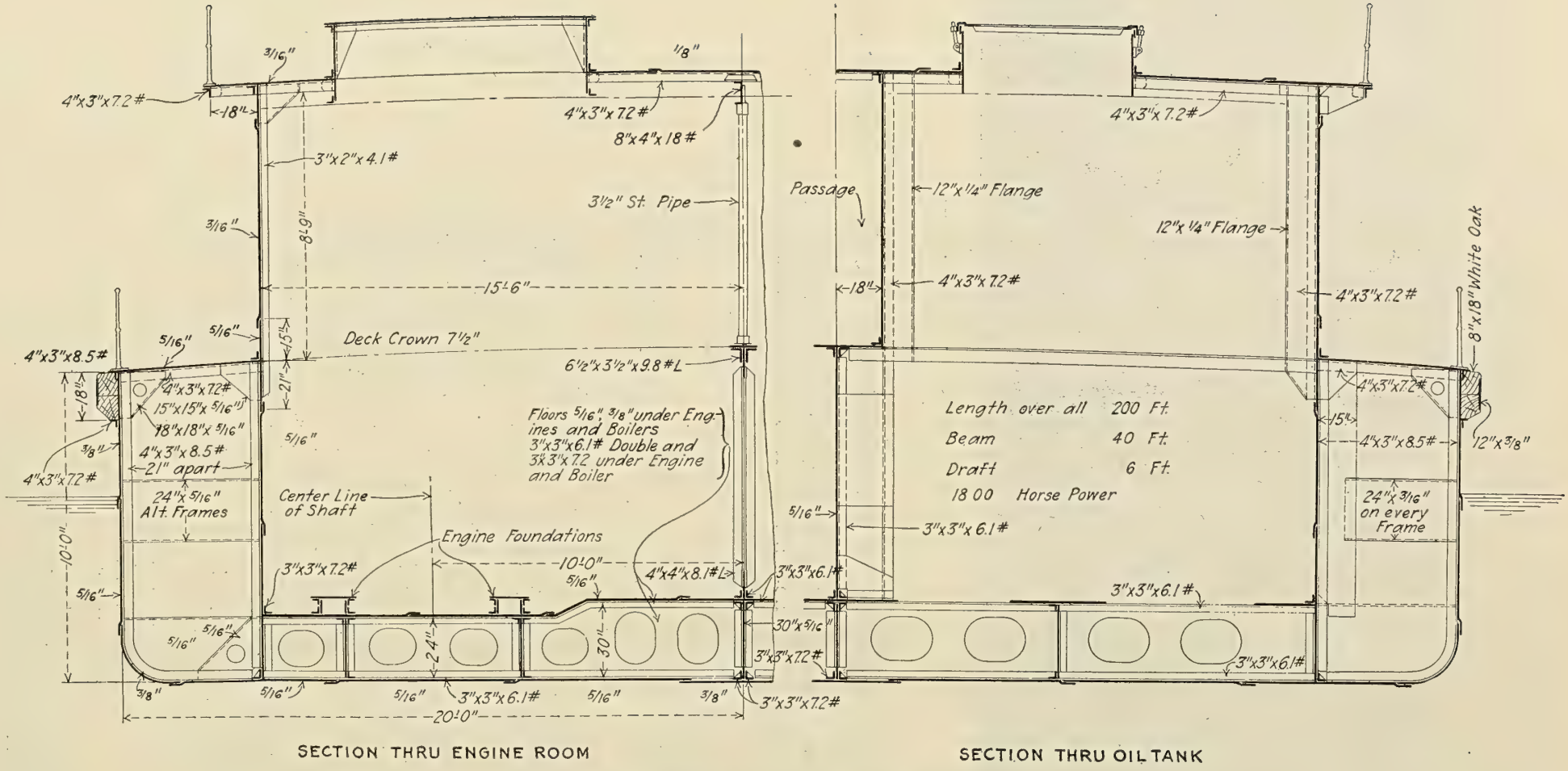
The boats are very strongly constructed of steel throughout in order to withstand the heavy towing which will be required. The framing is unusually heavy for vessels of this type, the floors being 30 inches deep, except in the way of the engines where they are reduced to 24 inches, and spaced 21 inches center to center. Double bottoms are provided extending from the aft engine room bulkhead to the collision bulkhead, except in the way of oil tanks where the tank top is omitted to provide for additional oil storage. The plating is ⅜-and 5/16-inch thick, double riveted. There are three longitudinal girders, one on the center line and one on each side 15 feet 6 inches from the center.

Main Propelling Machinery

Each vessel is driven by two triple expansion condensing engines having cylinders 15½, 25 and 44 inches diameter by 26 inches stroke with piston valves on all cylinders operated by the regular Stevenson link motion. The crank shafts are 8⅜ inches diameter of the built-up type with forged steel crank webs. Thrust blocks of the usual horseshoe type are fitted in with thrust shafts having six collars 14½ inches diameter.

Auxiliary Machinery

The auxiliary machinery consists of a cylindrical steel shell condenser having 2,400 square feet of cooling surface; a centrifugal circulating pump, with 10-inch discharge, driven by an 8-inch by 8-inch vertical engine; a vertical beam air pump 9 inches by 20 inches by 12 inches stroke; two vertical simplex feed pumps 7 inches by 10 inches by 12 inches stroke



SECTION THRU ENGINE ROOM

SECTION THRU OIL TANK

Fig. 4.—Midship Section, River Towboat *Natchez*

controlled by a float in the hot well; a Row & Davis feed water heater; two Engberg generating sets of 5 kilowatts and 10 kilowatts capacity; fire and bilge pumps; also a complete sanitary fresh water system in connection with a Permutit filtering and water purifying plant of 3,600 gallons capacity.

Refrigerating Plant

A complete Brunswick refrigerating plant of two tons capacity provides refrigeration for two cold storage rooms and small ice tanks.

Boilers

There are two Ward watertube marine boilers with 4,000 square feet of heating surface each, built for 250 pounds working pressure. The steam drums are 42 inches diameter by 12 feet long. Each boiler has 756 tubes 2 inches diameter and 42 tubes 4 inches diameter. The headers are constructed of steel plates 7/8 and 1 inch in thickness. Tube and handhole plates are stayed by the patent T-slot stay or division plate, no staybolts being used.

Oil Fuel

Each boiler is fitted with B. P. Lientz American oil furnaces and two Leahy burners. Steam is used for atomizing the oil. Forced draft is supplied by two wing blowers discharging into a wind box across the front of each boiler.

There are two fuel tanks with a total capacity of 319 tons of oil.

Propellers

There are two sectional four bladed propellers, each 9 feet 4 inches in diameter with a mean pitch of 8 feet 6 inches. The propellers work in tunnels of special design to provide an easy flow of water to and from the wheels.

Steam Capstans

Each vessel is fitted with four extra strong steam capstans of the usual Western river type, two located at the bow and one on each side just aft of the boilers .

Steering Gear

The arrangement of the rudders and steering gear requires special mention, there being four rudders located in the tunnels, two of them aft of the propellers and two forward. The rudders in each tunnel are controlled by an independent ram steering gear operated by oil under pressure, each pair of rudders being under control from the pilot house by means of a hand lever operating a floating valve on the ram, the position of the rudder being indicated by the position of the lever in the pilot house. Fig. 4 shows the general arrangement of rudder control.

The steering gear and independent operation of the rudders is the invention of Mr. T. R. Tarn.

The *Nantchez* developed during dock trials 2,237 indicated horsepower, the engines making 144 and 148 revolutions per minute, respectively, and the boilers operating under 250 pounds pressure. The safety valves blowing at intervals of about one and a half minutes showed that there was a large reserve of boiler power. Experience with vessels of this type shows that they will develop from 15 to 20 percent more power when operated in a tow of suitable size than during dock trials. This would give the vessels a total of 2,600 horsepower, which is nearly 40 percent above the contract requirements.

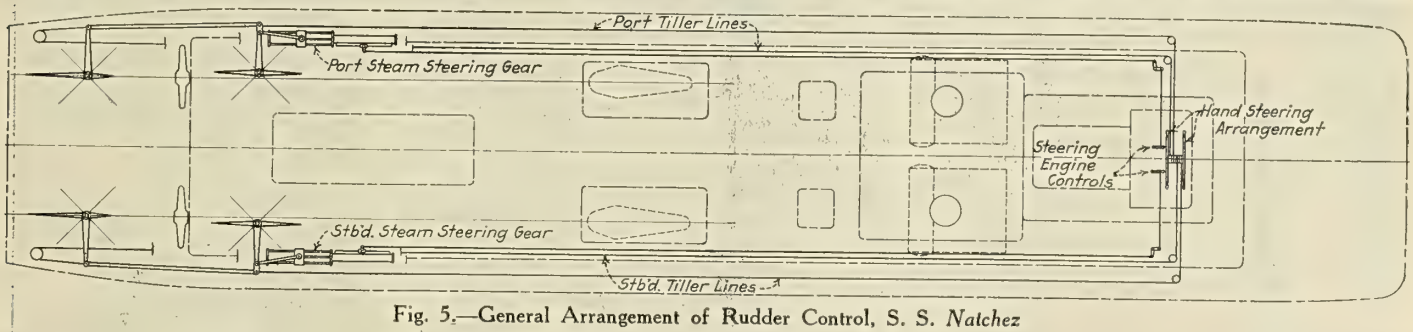


Fig. 5.—General Arrangement of Rudder Control, S. S. *Natchez*

New Board of Trade Survey Fees

THE Board of Trade fees under Section 443 of the Merchant Shipping Act for survey and approval of load line have been raised in the usual upward direction. The following tables show the old and new fees:

Old Scale — Gross Tonnage of Vessels	Classed Vessels £ s. d.	Unclassed Vessels £ s. d.
Under 300 tons	1 1 0	4 0 0
300 tons and under 1,000 tons	2 2 0	6 0 0
1,000 " " 2,000 "	3 3 0	10 0 0
2,000 " " 3,000 "	4 4 0	13 0 0
3,000 " " 4,000 "	5 5 0	16 0 0
4,000 " " 5,000 "	6 6 0	19 0 0
5,000 " " 6,000 "	7 7 0	21 0 0
6,000 " " 7,000 "	8 8 0	23 0 0
For every additional 1,000 tons	nil	2 0 0

New Scale — Gross Tonnage of Vessels	Classed Vessels £ s. d.	Unclassed Vessels £ s. d.
Under 100 tons	2 0 0	4 0 0
100 tons and under 300 tons	2 0 0	6 0 0
300 " " 500 "	3 0 0	8 0 0
500 " " 1,000 "	4 0 0	11 0 0
1,000 " " 1,500 "	5 0 0	14 0 0
1,500 " " 2,000 "	6 0 0	17 0 0
2,000 " " 2,500 "	7 0 0	20 0 0
2,500 " " 3,000 "	8 0 0	23 0 0
For every additional 1,000 tons up to 10,000 tons	1 0 0	3 0 0
For every additional 1,000 tons above 10,000 tons	nil	3 0 0

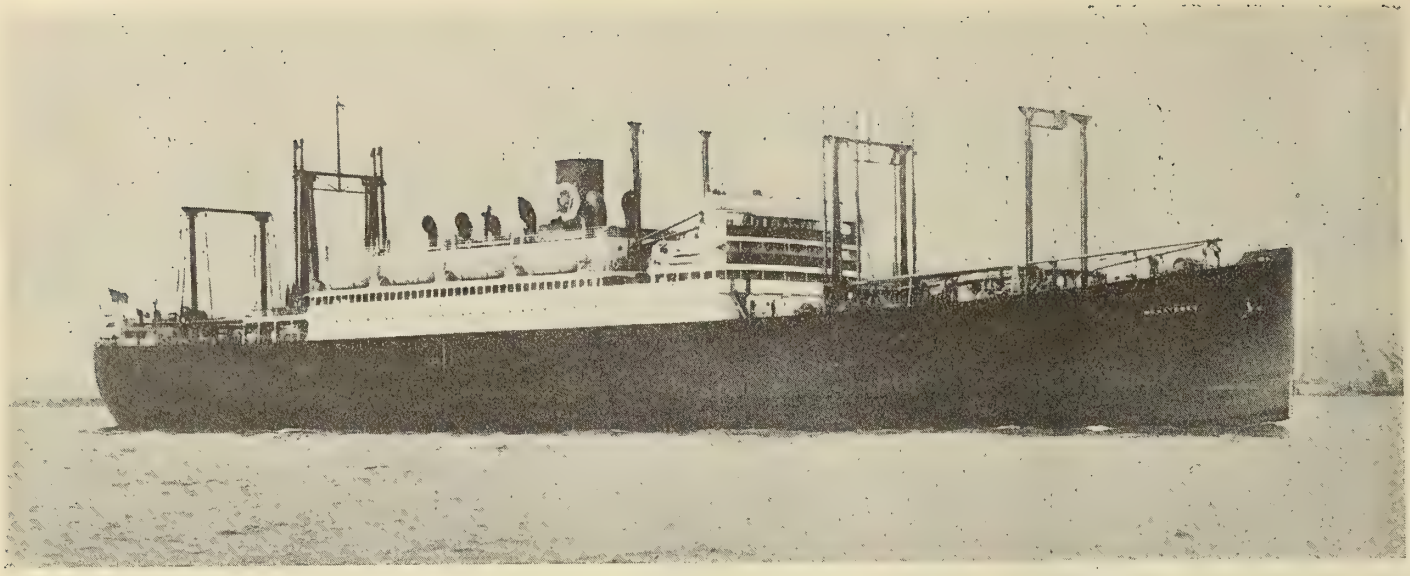
A special fee of £5 is also payable for the load line survey of an unclassed ferro-concrete vessel in addition to the fee prescribed in the third column of the above table.

The fee for an unclassed vessel should be charged for an unclassed wooden sailing or motor vessel *whether opened out for survey or not.*

When the fee as required by the last column of the scale above has been paid for the survey of an unclassed vessel, and when for special reasons a partial survey has been made and a certificate issued for a period not exceeding 12 months, only one-half of the full fee is payable for the completion of the survey for the renewal of the certificate of approval.

When owners or builders submit designs of new vessels and require provisional assignment of freeboard, the fee prescribed above should be paid according as the vessel is classed or unclassed. This will cover the final assignment of freeboard.

The fee for the inspection of minor alterations involving an alteration of freeboard in a vessel having a valid load line certificate is two-fifths the full fee chargeable.



(Photograph copyright by New York Shipbuilding Corp.)

Fig. 1.—Passenger Steamship *Wenatchee*

American Passenger Liner Wenatchee

The steamship Wenatchee, which was built by the New York Shipbuilding Corporation, Camden, N. J., and is now being operated by the Admiral Line between the Pacific Coast and the Far East, was originally ordered by the Government during the war as a hospital ship. Her design was, however, changed to a troop transport and when the war came to an end she was changed again into a de luxe passenger vessel.

WITH a length of 535 feet, a beam of 72 feet and draft of 36½ feet, the *Wenatchee* has a gross tonnage of 14,127, a net tonnage of 8,393 and can carry 250 cabin and 300 steerage passengers. She is an oil burner and is driven at 18 knots by Westinghouse turbines of 12,000 horsepower.

Undoubtedly, her most striking features are her luxurious fittings and her arrangements for the comfort and safety of her passengers and crew.

Her staterooms have twin beds, instead of berths, and are equipped with thermos bottles, shaving lamps, reading lamps over the beds, electric heat, steam heat, cold air (for use in the tropics), and in many cases, private baths. The public rooms, which are unusually spacious, are lighted by means of French windows, instead of ports, and most of the rooms have open fireplaces. In addition to the grand piano in the music room, there is a player-piano, for jazz, on the deck and

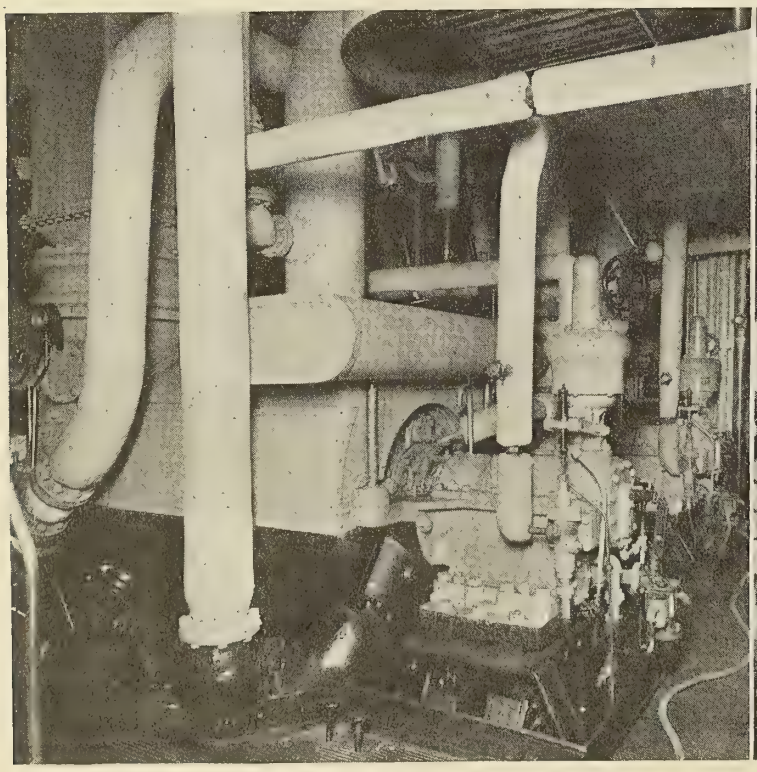


Fig. 2.—Main Turbines

Fig. 3.—Maneuvering Valves

a cabinet record player in the smoking room. The dining service is supplemented by a tea room and a veranda café. The furniture and finishings of all of the public rooms are very handsome and elaborate.

The broad decks are covered with rubber, and a wide promenade is glass-enclosed. A swimming pool on the boat deck will be especially popular on hot days and three hospitals—one for the passengers, one for the crew and one for contagious cases—will take care of those who fall ill on voyage.

There are eight cargo hatches, four forward and four aft. Each pair is served by a sampson post, instead of the usual king post, in order to expedite freight handling. The hatchways are large enough to admit a locomotive. The hull is divided into fourteen watertight compartments and the ship can float with any three flooded.

The *Wenatchee* is a twin screw vessel, and each propeller shaft is driven by a divided flow turbine rated at 6,000 horsepower. She has, therefore, four comparatively independent turbine elements, all four of which would have to be disabled before the ship could be disabled as far as turbine machinery trouble is concerned. An astern turbine, consisting of a single impulse wheel, is incorporated in each of the four turbine elements.

The turbines are designed for operation with steam at 250 pounds pressure with 75 degrees superheat and 28 inches vacuum, and consume 10.25 pounds per shaft horsepower at full-rated load.

The main condensers have an area of 8,000 square feet each, and will produce a vacuum of 28½ inches with 10,000 gallons per minute of circulating water at 60 degrees F. The circulating pump is turbine driven, as are also the condensate pumps. Vacuum is maintained by air ejectors. All of this auxiliary machinery is of Westinghouse make.

Electric current for lighting and power is furnished by four 50 kilowatt Westinghouse turbo generator sets. Each of these consists of a small impulse turbine geared to a slow speed direct current generator, the whole being assembled to form a compact unit.

Two sister ships of the *Wenatchee*, the *Sea Girt* and the *American Legion*, are being completed by the New York Shipbuilding Corporation and will be also equipped with Westinghouse turbines. Though these ships are just being completed, owing to the delays due to the several changes in their design, their propelling machinery was built during the war.

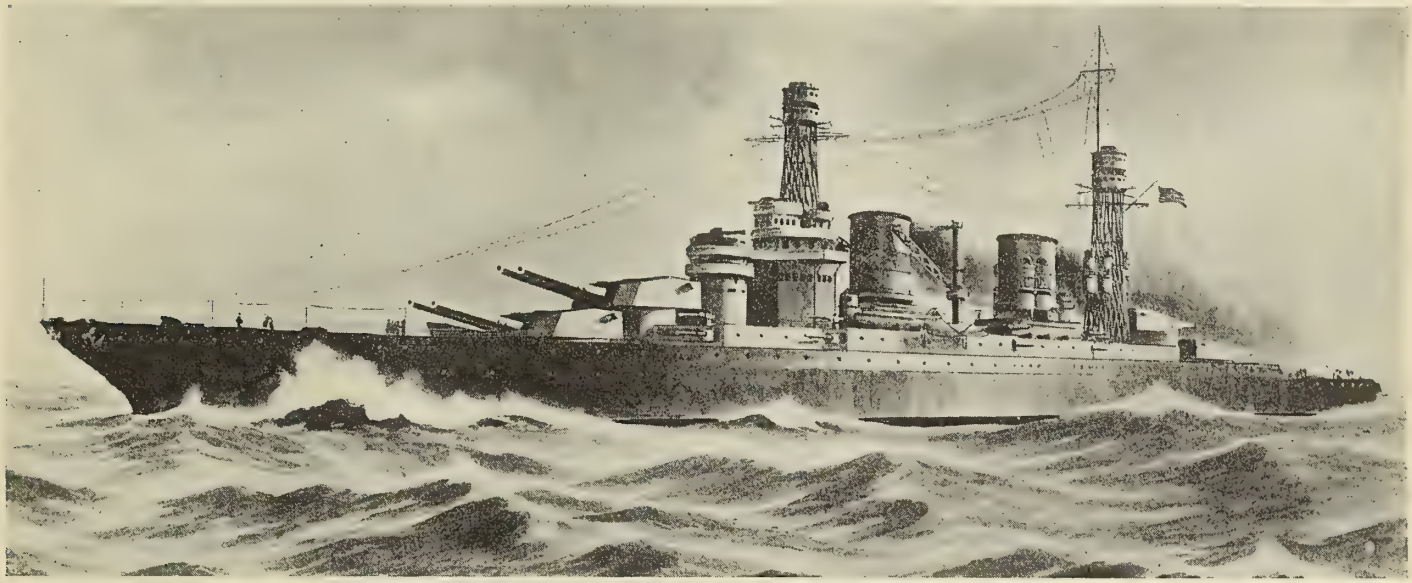
Dock Trials of Electrically Propelled Battleship Maryland Successful

THE superdreadnought *Maryland*, the third in order of completion of the electrically propelled battleships of the United States Navy, was given its official dock trials or first run under load at Newport News on May 2, 3 and 4, the trials proving satisfactory in every particular. The vessel is expected to go to sea late in June for the builders' sea trials and will be ready for acceptance by the Navy early in July.

In making the dock trials, the ship was secured to the dock with heavy cables and then the complete propelling machinery was set in operation in different combinations. The propelling machinery consists of two turbine generators, each designed to develop 11,000 kilowatts at a speed of 2,030 revolutions per minute to drive the ship at 21 knots; four induction motors, each rated at 7,025 horsepower at 170 revolutions per minute, which are directly connected with the four propeller shafts. The turbine generators also supply current for the operation of the electrically driven engine room auxiliaries.

During the trials, lasting 16 hours, with eight hour tests on each of the turbine-generator sets, the motors were operated separately and paired in various combinations, being subjected to strains equivalent to 21.5 knots at sea. The strain on the turbine-generators was equivalent to making 16 knots at sea, which represented the maximum amount of power that could be undertaken with safety.

The *Maryland* was built by the Newport News Shipbuilding and Dry Dock Company and the electrical equipment was manufactured by the General Electric Company. Two more battleships are being equipped at this yard with similar machinery, the *West Virginia*, which will be ready for its trial tests late in 1922, and the *Iowa*, which will be ready for tests in 1923.



United States Battle-Cruiser *Ranger*, as She Will Look When Completed

Battle-Cruiser Ranger

The photograph on this page, which is reproduced from a drawing, gives an excellent idea of the appearance of the United States battle-cruiser *Ranger*, now under construction at the yards of the Newport News Shipbuilding & Dry Dock Company at Newport News, Va. This vessel will be 874 feet long, displace 43,500 tons, and will have a speed of 33 knots. At this speed her Westinghouse electric propelling machinery will develop 180,000 horsepower. The main armament will consist of eight 16-inch guns.

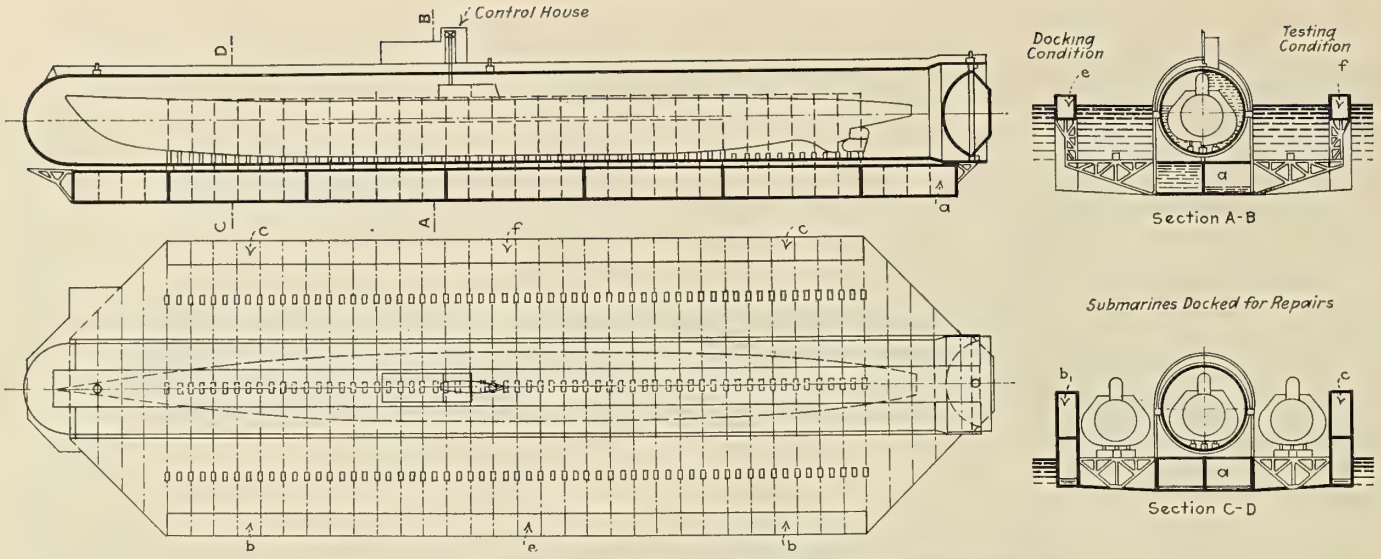


Fig. 1.—General Arrangement of Floating Dry Dock for Testing Submarines

Floating Dry Dock for Testing Submarines*

BY VON KLITZING

In 1916 construction was begun in Germany on a floating dry dock for testing submarines and during the summer of 1918 the dock was completed. By means of this dock submarines can be tested under pressures corresponding to a depth of 264 feet without the necessity of risking the loss of lives or vessel. In 1919, under the terms of the Armistice, the dock was turned over to the British Navy and is now being used for testing British submarines.

THE dock consists of a steel cylinder for testing submarines supported on pontoons with sufficient space on either side for docking a submarine for repairs. Pontoon *"a"* (Fig. 1.) has sufficient buoyancy to support the weight of the dock, the cylinder, and the submarines to be tested or repaired. The wing tanks *"b"* and *"c"* at the four corners of the dock serve to keep the dock on an even keel while being raised or submerged. The connecting tanks *"e"* and *"f"* provide stability when the dock is submerged, the submarines being tested with the dock partially submerged.

Testing Cylinder

The testing cylinder has a clear diameter of 39 feet 5 inches and a length of 380 feet 7 inches. One end is closed by a hemispherical bulkhead and the other end is open. The open end is fitted with a steel ring sheathed with hardwood. The cylinder is built up of steel plates with steel stiffening rings spaced 39.37 inches. All seams and butts are treble riveted and all rivets are countersunk on the inside of the cylinder. Three domes are fitted at the top of the cylinder, one in the center and one at each end, for collecting the air which is expelled when the cylinder is filled with water. Air pipes lead from these domes to the control house where they can be closed by means of cocks as soon as the cylinder is full. The middle dome is fitted with a safety valve. Access to the submarine to be tested is provided by a trunk (Fig. 2). Three manholes are fitted for access to the interior of the cylinder. Four large electrically operated slide valves provide for rapid drainage of the cylinder.

Caisson for Closing the Cylinder

The caisson for closing the open end of the cylinder consists of a floating vessel whose periphery is elliptical. One side of the caisson is spherically shaped and the other side is shaped like the frustum of a cone (Fig. 3). The spherical side takes the pressure while the other side is so formed as to give the proper stability to the caisson when floating. At the periphery of the caisson a steel surface is provided which lies against the wood sheathing of the steel ring at the end of the cylinder.

When pumping water into the cylinder, the pressure on the inside forces the caisson against the cylinder ring and thus prevents leakage. A counterweight, which can be rotated, is mounted inside the caisson. By means of a hand gear this weight can be rotated so that the caisson is turned through an angle of 90 degrees. It is necessary to turn the caisson through 90 degrees in order to get it through the similarly shaped elliptical opening of the cylinder.

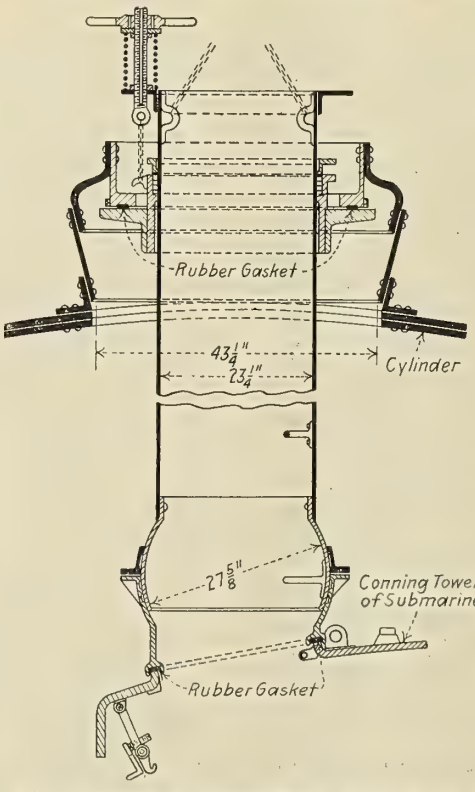


Fig. 2.—Details of Trunk Which Gives Access to Submarine Under Test

After the caisson has been brought into the cylinder it is

* From "Zeitschrift des Vereines Deutscher Ingenieure."

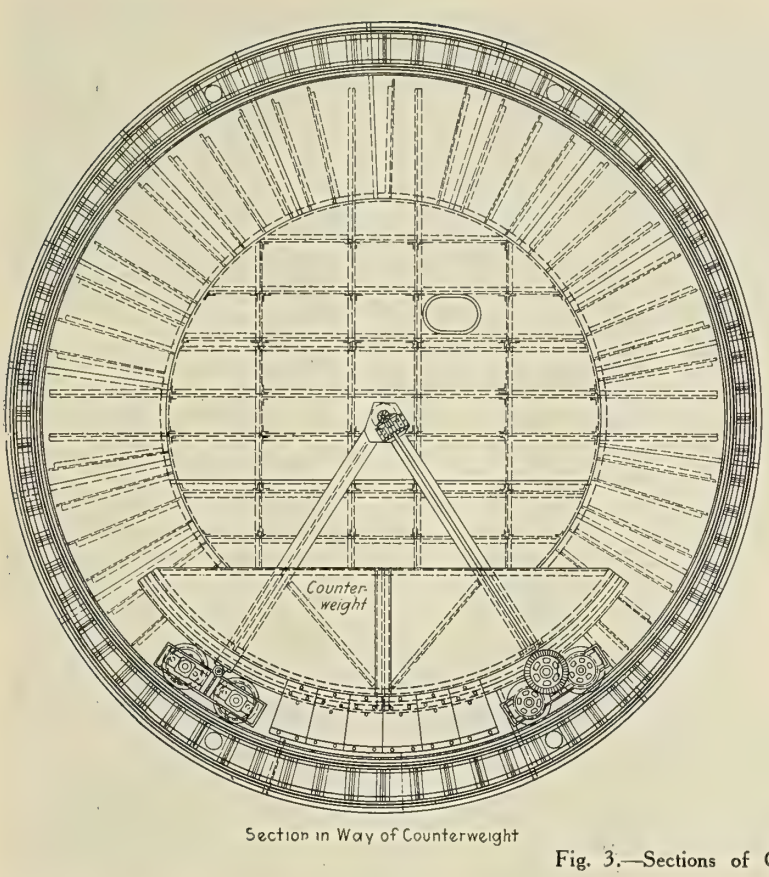


Fig. 3.—Sections of Caisson

returned to the upright position and brought against the cylinder ring so that the flanges are in contact all the way around. It is held in this position by dogs at the outside of the cylinder and pumping then begins. The caisson is divided into watertight compartments which are emptied or filled with water in order to regulate its floating position.

A roomy control house is located over the middle of the cylinder and contains all the apparatus necessary for raising or submerging and for testing the submarines. The apparatus is similar to that in use on modern floating dry docks and includes levers for the operation of the valves, draft gages for the different tanks and for the fore and aft drafts of the dock, hydraulic depth gages, and switches for the operation of the high and low pressure pumps and of the large slide valves for draining the cylinder.

Pumping Arrangement

Two low pressure pumps are used for raising or submerging the dock and for filling the cylinder. Two high pressure pumps are provided for increasing the pressure within the cylinder when testing submarines. The suction and discharge piping is arranged in two systems, one for each side of the dock and one low pressure pump is connected to each system. These systems are cross-connected so that one pump can be used for both. The discharge sides of the pumps are connected to the cylinder so that water pumped from the pontoons may be transferred to the cylinder without altering the draft of the dock. The various valves are controlled by means of rope pulls. The low pressure pumps are located near the bottom of the wing tanks and are driven by alternating current motors at 750 revolutions per minute. These motors are controlled from the control house.

The high pressure pumps are located in a small house beside the control house and have independent suctions from outboard. They are driven by motors, which are controlled from the control house, at 3,000 revolutions per minute. By means of a control valve, the pressure within the cylinder can be maintained at any desired point up to 117.5 pounds per square inch, which corresponds to a sea depth of 264 feet. The high pressure pumps are capable of attaining the pressure of 117.5 pounds in ten minutes.

The slide valves for rapid drainage of the cylinder have a 39.37-inch diameter opening. They are opened and closed by motors controlled from the control house. The position of the slide is shown at all times by an indicator in the control house.

Operation

For testing submarines, the dock is first submerged to a depth of about 40 inches above the center of the cylinder. The submarine is then towed in and the dock raised until the vessel rests on the keel blocks. Then the vessel is stayed from the sides and from above.

When the caisson has been floated into place and clamped and the access trunk connected up, the low pressure pumps are started and the cylinder is filled. The draft of the dock remains constant, as the water is transferred from the pontoons to the cylinder. The air escapes through floating valves in the domes at the top of the cylinder. When the water reaches the domes, the valves automatically close and the air which remains can escape only through the air pipes leading from the top of the dome to the control house. When the cylinder is completely filled water escapes through the air tubes in the control house. The tubes are then closed, the low pressure pumps stopped, and the high pressure pumps run until the desired pressure is obtained.

If submarines are to be docked for repairs on either side of the cylinder, the operations are like those of a floating dry dock. It is not necessary to have a vessel on each side of the dock, an even keel being maintained by water ballast.

When the dock was put in commission by the German Navy, tests were run on it with the following results: The time required for filling the cylinder was one hour and forty-two minutes; seven minutes were required to raise the pressure to 117.5 pounds; and six minutes were required to reduce the water level within the cylinder to the center of the cylinder.

Fig. 1.—200-Ton Flanging Press in Action at Boiler Shop of Federal Shipbuilding Company

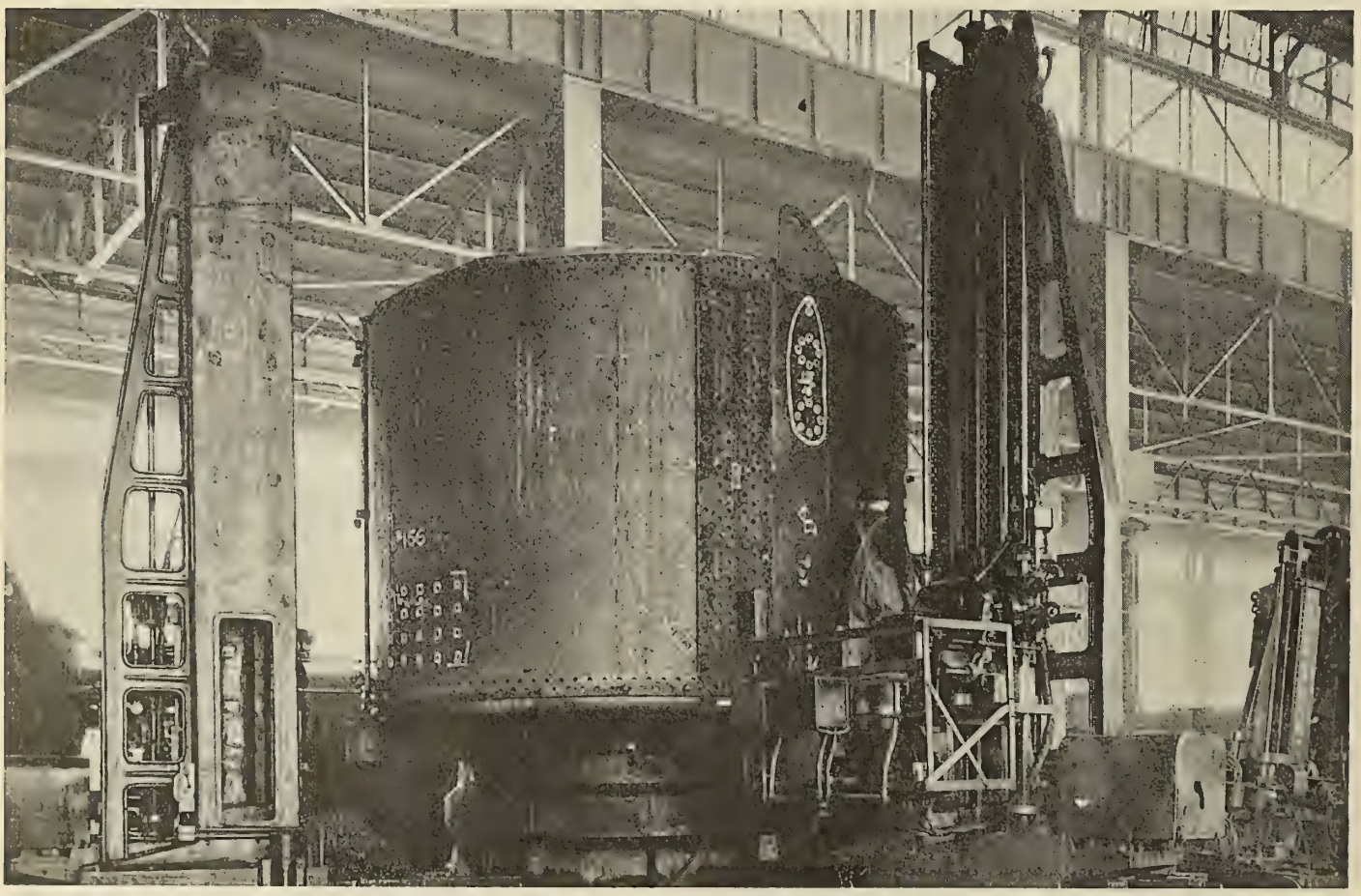


Fig. 2.—Triple Head Shell Drill, Having a Capacity of Shells from 8 Feet to 18 Feet in Diameter and 14 Feet Long

Quantity Production of Scotch Marine Boilers

With a normal output of three Scotch marine boilers a week, the boiler shop of the Federal Shipbuilding Company ranks with the most efficient shops in the country. The methods and equipment employed in the accomplishment of this construction, which for boilers of this type might be termed quantity production, are outlined in the accompanying article. While boilers for the ships under construction in the shipyard are being built, the stacks, uptakes and tanks for these ships are also fabricated in the boiler shop.

THE boiler shop of the Federal Shipbuilding Company, Kearny, N. J., primarily intended for Scotch marine boiler, stack, tank, uptake and light plate fabrication, is one of the largest in the country and is equipped with the best types of modern machinery for the efficient handling of work through the shop. Working normally with one eight-hour shift of 250 men, the output of the plant is three boilers a week. With the addition of another shift of about 100 men it is possible for the plant to turn out boilers on the basis of 200 a year. Since September, 1919, up to the present time, 235 boilers, most of them in excess of 15 feet in diameter, have been built in the shop. In addition, the stack, tank and uptake work for all vessels built in the Federal shipyard was carried on at the same time as the construction of boiler equipment.

The whole object in the arrangement of the shop, its equipment and the routing of material in the process of fabrication has been with the view to maintaining work on a production basis.

Structural Details of Shop

The building is a steel and terra cotta structure 585 feet long and 161 feet 6 inches wide, comprising a center bay 63 feet wide and 70 feet high below the roof truss. Two side bays, each 63 feet wide and 40 feet high flank the center. Partial extensions are arranged on the west end and south side for heating furnaces, and on the opposite side for the office, tool room, locker room and wash room.

For a distance of 85 feet the west end of the shop is free from columns and forms the flanging department. Next to this space central columns divide the main bay into two runs. For a distance of about 50 feet this section forms the riveting department. The middle stretch of the main aisle contains shell drilling equipment and forms the assembly floor. At the east end is the department in which hydraulic testing of the completed boilers is carried on. The north bay of the shop forms a department for the fabrication of light plate work. Standard gage railroad tracks enter each bay of the shop at the east end, and the north bay of the shop at the west end. Transverse 36-inch gage tracks connect the main aisle with the two side aisles.

Routing of Material

The shop is laid out for a straight line flow of materials, the direction being from the east end of the south bay to the west bay and then back through the main bay to the testing floor. When it reaches this point, the boiler is ready for shipment or installation in a vessel.

The north bay of the shop is utilized for tanks, stacks, up-

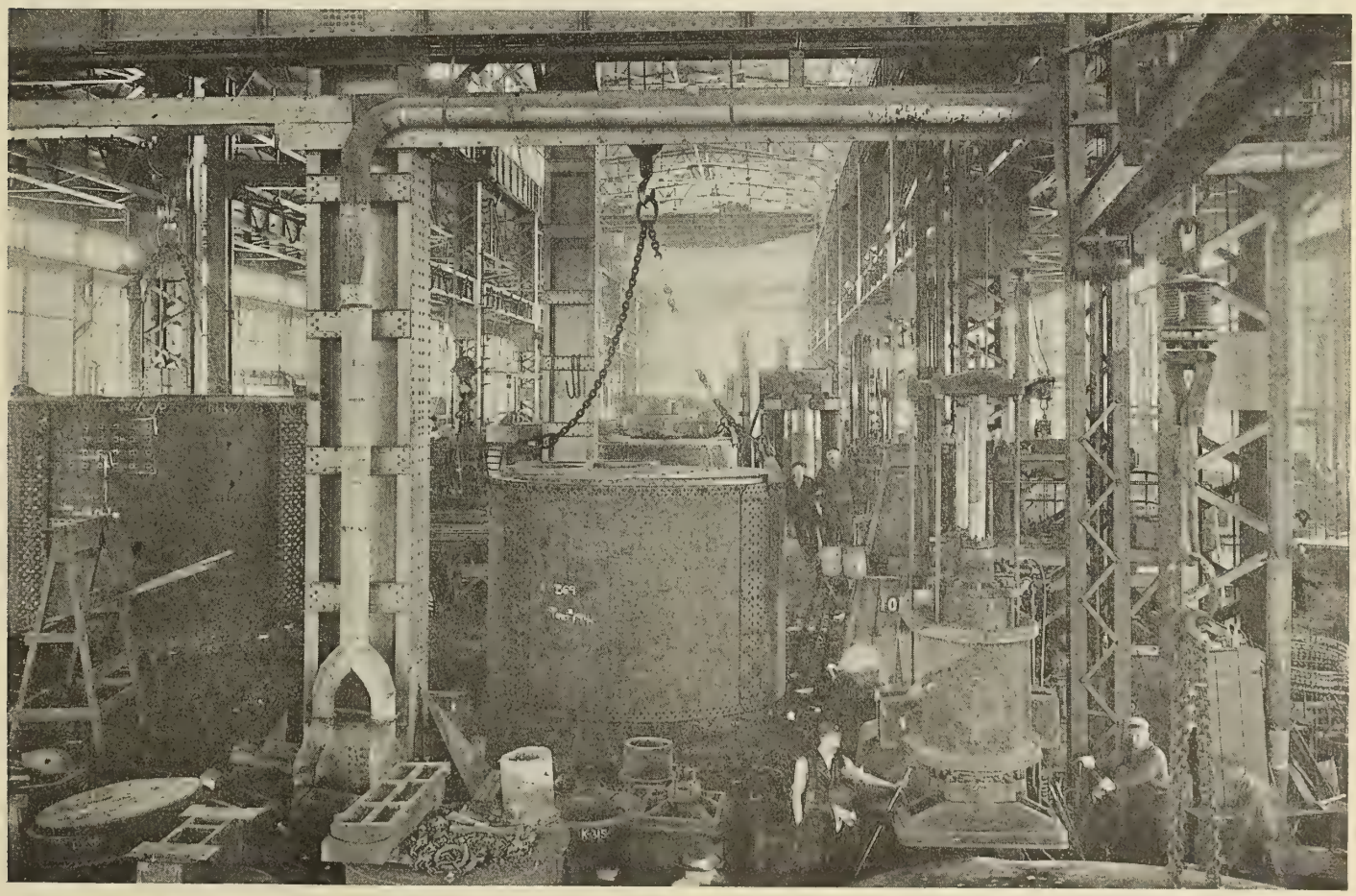


Fig. 3.—Looking East in the Main Bay of Boiler Shop at Federal Shipyard, Showing the Riveting and Assembly Departments

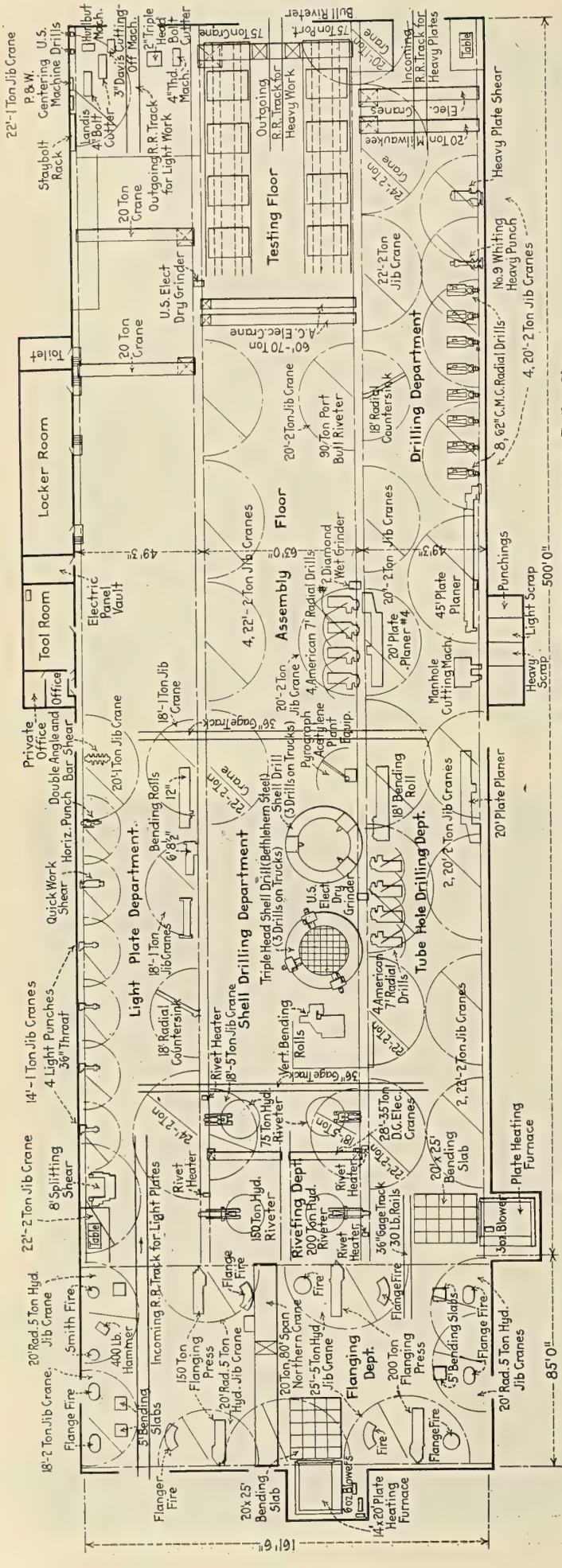


Fig. 4.—Arrangement of Departments and Tool Equipment in the Federal Shipbuilding Company Boiler Shop

take and other light plate fabrication. Production processes are carried out completely in this bay from the plates which enter the plant at the west end to the finished product which is taken from the plant on railroad trucks at the east end.

Machine Equipment of Plant

Power at 13,000 volts is supplied to a central sub-station in which current is transformed, converted and distributed to the entire shipyard. The boiler shop uses 400-volt, 3-phase, 60-cycle alternating current as well as 230-volt direct current. All electric cranes are operated at 230 volts. The lighting current is 110-volt. The oxy-acetylene and electric welding processes are used extensively in the shop on both boiler and plate work. Flanges on heads and tube sheets are trimmed with the pyrograph, an automatic oxy-acetylene cutting machine specially designed for this class of plate work. The radiograph is used for making circular and irregular cuts in plates. A special feature of the shop is the jib crane equipment, which consists of nine hydraulic and thirty-eight hand jib cranes of from 1 to 5 tons capacity and with radii of action from 14 to 24 feet. The shop is piped for compressed air, which is used at a pressure of from 90 to 100 pounds. Hydraulic pressure of 1,500 pounds is available for operating the flanging presses, bull riveters and other hydraulic machinery.

The east bay is served by two 20-ton Milwaukee electric cranes which handle material the length of the shop as far as the flanging department. Ranging along the south side of the south bay there are a set of heavy plate shears, a number 9 Whiting heavy punch, eight 62-inch radial drills, a 45-foot plate planer, a manhole cutting machine and a 20-foot plate planer. In addition, this bay contains one 18-foot radial countersink, a second 20-foot plate planer, a set of 18-foot horizontal bending rolls and four American 7-foot radial drills which are used for drilling tube holes and the like. A 20-foot by 25-foot bending slab is also located in the north bay immediately in front of a 14-foot by 20 foot plate-heating furnace in which the heads are annealed. The flanging department at the west end of the plant is served by one 20-ton, 80-foot span, Northern electric crane. Two 200-ton flange presses which will turn a 12-inch flange on 1½-inch plate and two 150-ton hydraulic presses are installed here. This department also has one 400-pound hammer, a 14-foot by 20-foot plate heating furnace and a 20-foot by 25-foot bending slab, as well as five 5-foot bending slabs and ten flange fires.

In the riveting department there are two 75-ton hydraulic riveters one 150-ton and one 200-ton riveter; the latter has a gap of 14 feet 6 inches and a stroke of 12 inches. Rivet heaters are located adjacent to each riveter. In addition, two 90-ton portable riveters are available in the shop wherever they are needed.

This department is served by two 28-foot span, 35-ton cranes. The arrangement of the rails for these cranes permits the full span cranes of the main bay to drop material within the reach of the two cranes in the riveting department, so that the main cranes are released for other work, where in most shops they are utilized for handling material, being worked in the bull riveters.

The remaining equipment in the main bay includes a set of vertical bending rolls for shell plates up to 162 inches wide by 1⅞ inches thick; two sets of triple-head shell drills are installed, one of which was built in the yard and the other of Bethlehem make. The latter will take shells from 8 feet to 18 feet in diameter and 14 feet long without reversing ends. A Davis-Bournonville pyrograph for oxy-acetylene cutting of flanges on heads and the like is located near the shell drills. The main bay is served by two 70-ton electric cranes which have a 60-foot span and two 35-ton trolleys, and one 75-ton Northern electric crane having two 50-ton trolleys. Several

United States dry grinders and Diamond wet grinders are located through the shop. A battery of four American 7-inch radial drills completes the equipment in this section.

In the north bay, used for light plate fabrication, the laying-out table is located on the west end, and from this point following through the department there are a set of 8-foot gate shears, an 18-foot radial countersinking machine, four light punches having 36-inch throats, one Quickwork shear, one horizontal punch, one double angle and bar shear, one brake bender, one 6-foot 8½-inch bending roll, two 20-ton Milwaukee electric cranes. The east end of this bay contains machines for making staybolts, threading stay tubes and the like. The equipment here includes one P. & W. centering machine, two United States drills, one Hurlbut machine, two Landis 4-inch bolt cutters, one 3-inch Davis cutting-off machine, one 2-inch triple-head bolt cutter and one 4-inch threading machine.

Every precaution has been taken throughout the shop to guard machine operators against accident. Locker and washroom facilities are very complete for the convenience of the men. The central dispensary service of the shipyard is always available for the men in the boiler shop as well as all of the other shops in the yard.

New Dry Dock at Gothenburg

FLOATING DRY DOCK NO. 2, recently built by the Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, is of steel throughout of the following principal dimensions:

Length of pontoon	416 feet 6 inches
Length of wings	343 feet
Width over all	90 feet
Width between wings at pontoon deck	66 feet
Draft over keel blocks	21 feet
Height of keel blocks	4 feet
Depth of pontoon amidships	11 feet 7 inches

The lifting capacity is about 7,500 tons, i.e. ships with a carrying capacity of about 14,000 tons deadweight can easily be docked.

Construction of the Dock

The dock is built in three sections for self-docking purposes and these sections are bolted together. The middle section is docked in the two end sections and both end sections in the middle section for upkeep of the submerged parts of the dock.

The pontoon is divided into 18 watertight compartments by two longitudinal and a number of transverse bulkheads. A center bulkhead, not watertight, is fitted for taking the load of the keel blocks and also side girders and web frames are built for taking the load, when the keel blocks are removed for bottom repairs and for the bilge blocks.

The keel blocks, 103 in number, are made of oak of special design with wedges to be easily removed. Thirteen pairs of bilge blocks, which can be drawn with windlasses from the wing decks, are fitted.

Six pairs of side shores are mounted in the wings for placing the vessel in position before pumping and for shoring up the vessel when docked.

Pumping Machinery

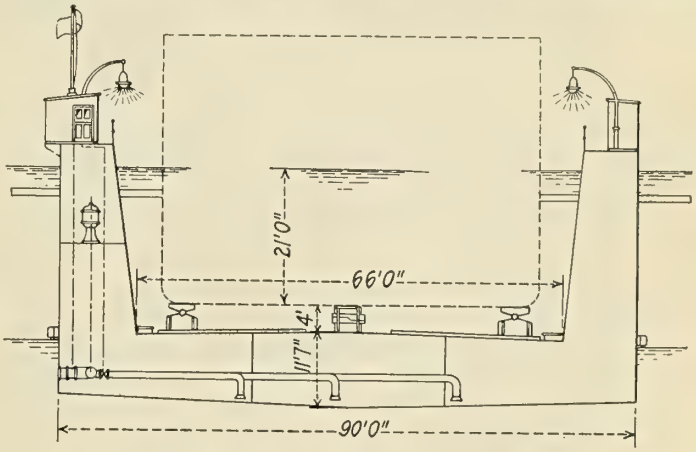
The pumping machinery consists of two vertical centrifugal pumps in the middle section, each of which is driven by a 150 horsepower electric motor, and one similar pump driven by a 75 horsepower motor for each of the end sections. The total pumping capacity is about 250 tons per minute, allowing the lifting of an 8,000-ton deadweight vessel in about 50 to 60 minutes.

The valves for all compartments are controlled from a controlling house on one of the wings where also gages, showing the height of water in the separate compartments, inclination and sagging indicators are mounted.

One electric driven tank-filling pump with a capacity of 150 tons per hour is placed on the motor deck beneath the controlling house. Four-inch pipes for compressed air are fitted along both wings at the pontoon deck for the various repair tools.

In one end of the dock a 15-ton electric crane is mounted for lifting propellers and repair materials ashore.

The motors are built for three-phase alternating current, 380 volts, 25 periods, the power being delivered to a separate transformer station on shore from The Trollhättan Falls



Section Through New Swedish Dry Dock

near Gothenburg. Here, also, the air compressors for the dock are placed.

The new dock is anchored alongside the first floating dry dock which has a capacity for lifting vessels up to 3,200 tons deadweight. The first ship was successfully docked in the new dock on February 4. With the addition of this new dock the possibilities of carrying out ship repairs at the yard are greatly increased, as the dock can accommodate any of the cargo vessels coming to Gothenburg.

Notes on Operation of Turbines*

BY E. H. B. ANDERSON†

1. When starting up new installations, it is a good plan to run the turbines disconnected up to about 20 percent above full speed revolutions, and in naval work this is standard practice.

2. I advise shutting down instantly when a bearing shows signs of heating, or if vibration begins to occur, or if a bearing shows that there is not a steady flow of oil passing through.

3. Many troubles with turbines are caused by improper drainage, and if water in bulk is kept out of the exhaust wells of the casings and oil is kept flowing to the bearings, then the engines will run well.

4. Water coming over to the turbines, due to boilers priming, will not cause blade stripping, but sediment, etc., will probably choke the blading of the low pressure turbine.

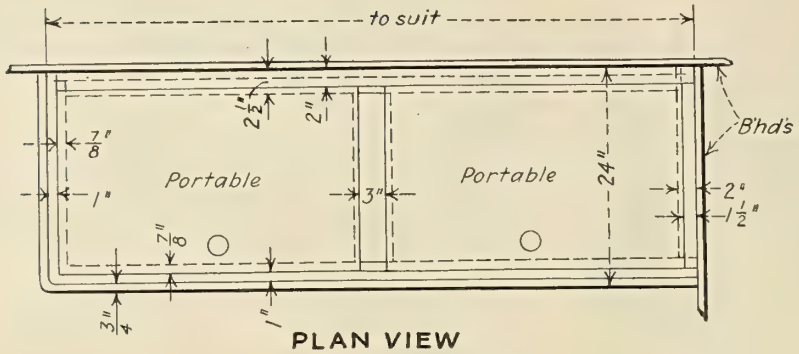
5. As a general rule, never use water on bearing caps to cool same, and it is much better to shut down and open up bearings for examination. When water is used on bearing caps, place bagging or waste on the metal and allow the water to trickle over the waste. In this way water will not find its way over to the steam belts of the turbine casings.

* From a paper on "The Parsons Marine Steam Turbine" read before the Ocean Engineers' Beneficial Association No. 80, New York.

† Parsons Marine Steam Turbine Company, New York.

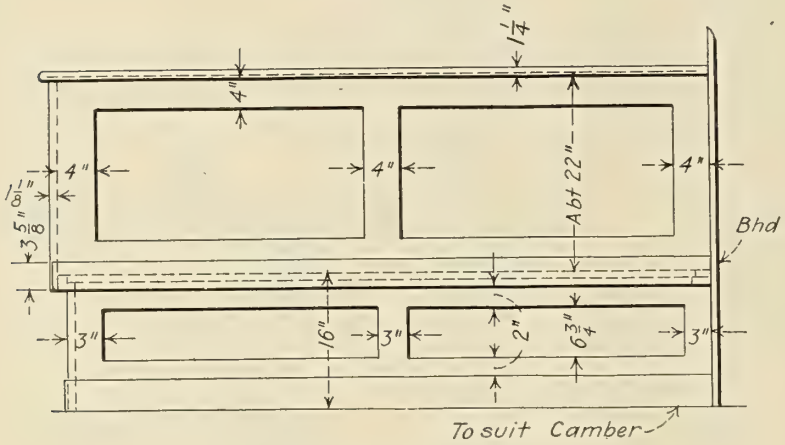
Ship Joiner Plans

Transoms

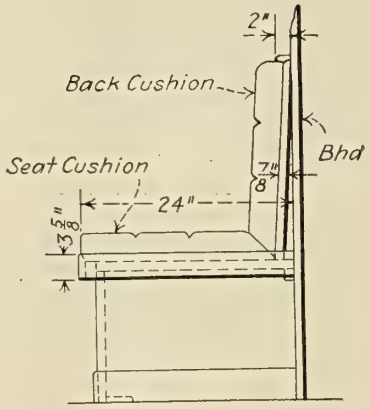


PLAN VIEW

TYPE "A"
One End Open

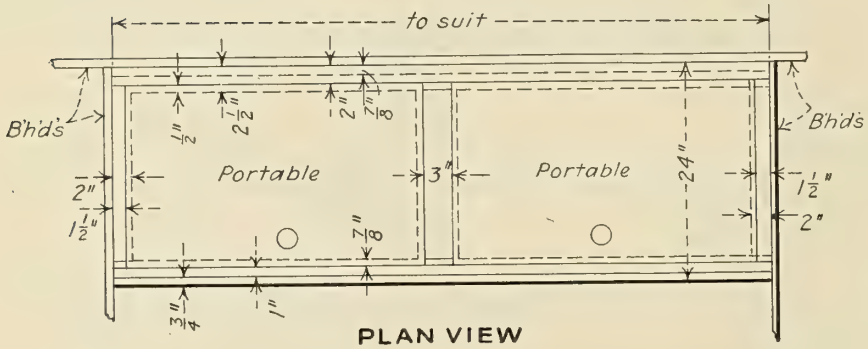


FRONT ELEVATION



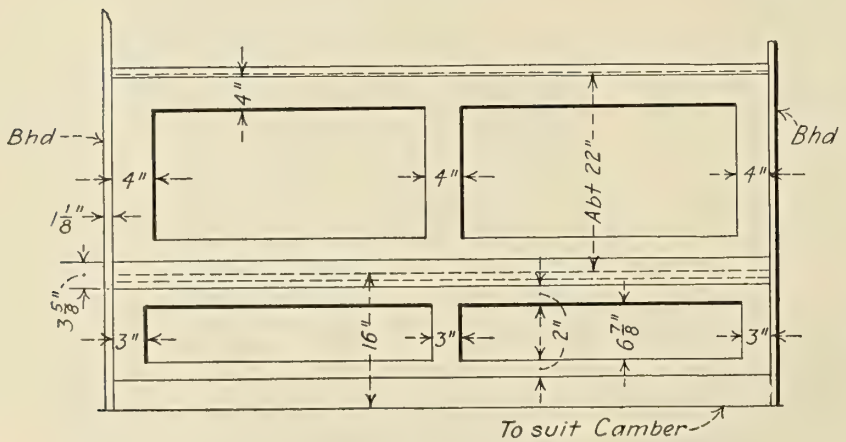
END VIEW
Type "A" Only.

NOTE: *Exact Size of Cushions to be taken from Work.*

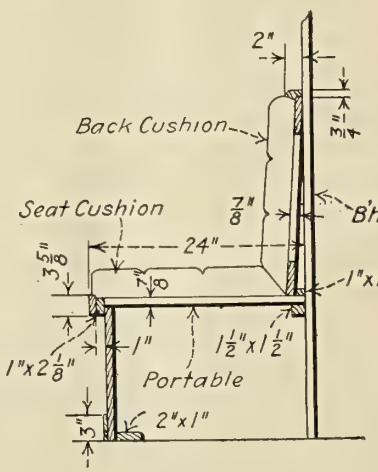


PLAN VIEW

TYPE "B"
Both Ends Closed in



FRONT ELEVATION



SECTION
Type "A&B"

The Naval Architects' Meeting in London

Brief Review of the Papers and Discussion at the Annual Spring Meeting of the Institution of Naval Architects

BY C. H. PEABODY, DR. ENG.

As Great Britain is a leader in naval and maritime construction the recent meeting of the Institution of Naval Architects in London is notable not only for the variety and importance of the papers presented, but also for the assemblage of the leading men in the profession and practice of shipbuilding.

With so much important material at hand only a brief review can be attempted here; American shipbuilders will find much to read and ponder when the full proceedings are available. Perhaps certain side lights will be found as illuminating as the regular proceedings. For example, the report of the Council showed a subscription of $7,000 for the past year to the research fund of the William Froude Tank at South Kensington, a tank established by the generosity of Mr. Lanow. The main business of this tank is the investigation of general problems for which governmental and commercial tanks have scant leizure.

German Naval Construction

The first two papers read were somewhat similar in nature relating to German naval design. The first, by the Director of Naval Construction, Sir Eustace T. d'Eyncourt, was entitled "Notes on Some Features of German Warship Construction," and the second, by S. V. Goodall, on the "Ex-German Battleship *Baden*." Mr. Goodall's description of the *Baden* deserves special mention for completeness and excellence. From these papers and their discussion was drawn the conclusion that except in certain details the British led in the construction of all classes of warships, including submarines. A more important conclusion for us is that the sea is and will be dominated by the battleship, in spite of the predilection of certain "ancient mariners" for submarines and air craft only. The submersible battleship of which much was heard during the war appears to be and probably will remain a myth.

The paper by R. J. Walker and S. S. Cook on "Double Reduction Gears" is most opportune and most encouraging; the fact that some American gears built during the war were unsatisfactory was not considered important; inexperience and haste were responsible. This paper was published in the May issue of this magazine, and need not be discussed here.

Strength of Ships

Three papers were concerned with strength of the ship or its parts and may be discussed together. One was by W. R. G. Whiting on the "Strength of Submarines," another by A. M. Robb on "Deflections of Bulkheads and of Ships," and the third by Professor T. B. Abell on the "Framing of a Ship."

Taking the last paper first, we have here a radical proposition that appears to lead to a considerable reduction in the material that must be worked into a ship. The author starts with two propositions concerning thin plating divided into rectangular panels, with the conclusion that if one system of frames is spaced three times as far apart as the other it lends but little additional support to the plate. So brief a statement of Professor Abell's principles is, of course, incomplete and would be misleading if we proposed to apply it ourselves, but it may enable us to appreciate his proposal to use only transverse framing in the hull of a freighter. He raises the question whether longitudinal girders may in such case be dispensed with? Can we leave out center girders, side keelsons, margin plates and bilge keelsons? Calling to mind that iron ships were built on the experience of wooden shipbuilding and that the construction of steel ships has never broken away entirely from tradition, the answer to this question can be had only after a radical reconsideration of all the habitual methods of steel shipbuilding; one wonders where modern longitudinal framing comes into such a scheme.

Strength of Submarines

Jumping back to the first paper of the trio, by Mr. Whiting, we find that it gives a thorough discussion of the stresses in the framing of submarines, which are due mainly to the hydrostatic pressure at maximum allowable submergence, for which purpose a fairly complete analysis of elliptical forms has been worked out.

The advantage claimed for his theory is that the relative effect of variations in the design can be readily predicted; as compared with Dr. Bruhn's more general method, based on the theory of least work, the processes are visible and the actual calculations are less intricate and more accurate. The same remark applies to the comparison with Professor Hovgaard's analysis, based on the principle of continuity. Mr. W. E. Noble in discussing the paper gave his opinion that the safe-diving depth of submarines is likely to increase with a linear dimension, and that there must be a natural limit on size. As a side light we may ask what influence this matter may have on the possibility of designing submersible battleships?

Deflection of Framing

The other matter of deflections of the framing of ships and their parts we shall always have with us. This is because the statement of our problem always remains indefinite. A bridge engineer may know or may assume a definite loading; the one radically indefinite factor being wind pressure. He may be reasonably confident of his anchoring. The ship designer finds for the general framing of the ship only a conventional method of loading of which he can be confident only that it never will occur in service. The loading of bulkhead frames can be neatly stated and it may so happen after an accident to the ship, but he can have no confidence in the end security of his girder. Now as to what really happens, we know that the ship's framing will be loaded some way in service, and if deficient the framing or fastenings are likely to show up any insufficiency. A ship that is lucky may never have a stress on its bulkhead frames and we have nothing to depend on except incomplete calculations and insufficient experiments. This preamble will show the importance of the paper by Mr. Robb, since he reports the results of investigations of deflection curves of bulkead stiffeners and of ships.

Mr. Robb concludes that the beam theory applies to the case of the bulkhead stiffener subject to the assumption of about 60 percent constraint at the ends, a stress of 8 tons per square inch and an effective width of plating equal to about 25 times its thickness.

Deflections of Ships

The author says that the deflections of ships for the purpose of determining the modulus of elasticity have rarely been made. The discussion of such as have been made are therefore the more important; this applies to this part of Mr. Robb's paper and to the conclusions he draws. There

are two items that come into the discussion of the deflection of the structure of a ship: (1) Deflection due to shear and (2) slipping of riveted joints. Now ships do not show permanent set as would occur did the riveted joints slip, and experiments on riveted joints do not show slipping until they are ready to fail in the testing machine. On the other hand the shear on a ship is borne chiefly by the plating, which is relatively thin, and the discrepancy between observed deflection and deflection computed without taking account of shearing may reasonably be charged to that omission.

Life Saving Requirements

The disaster of the *Titanic* brought a demand by public opinion that ships be made safe or at least safer, and that boats enough be carried for passengers and crew. Two papers presented at the Institution of Naval Architects deal with the attempts to meet these requirements. They are: "Life Saving at Sea," by E. W. Blocksidge and "Spacing of Bulkheads," by K. G. Finlay.

Since ships in service cannot be reconstructed, and since new methods of construction demand careful consideration, the investigation of the question of the safety of the ship has proceeded in an orderly manner and has resulted in the "factorial" system of watertight subdivision recommended by the International Convention. Though the leading naval architects and shipbuilders of all nations served on the convention, and though their recommendations were carefully matured, experience showed that much was left to be desired. Last summer a paper was presented by Sir Westcott Abell, the chief surveyor of Lloyd's, making certain suggestions, and now the present writer proposes a new method which he calls "odds on." In the discussion certain difficulties arising from attempts to apply the convention recommendations were reported, especially for freighters, but the general opinion appeared to be that those recommendations should be modified rather than replaced.

Lifeboats

The matter of ships' boats has received very different treatment with less satisfactory results. Legislators could and did require that all ships should carry boats enough for passengers and crew and shipowners had to meet the letter of the law as best they could. The first effect was to clutter the decks of passenger ships with all kinds of boats, real boats and collapsible boats, with little attempt to determine whether the boats could be launched or what they would be worth if that were possible. Immediately, inventors got busy devising all kinds of launching apparatus; some of them were good and have been extensively installed. The design and construction of lifeboats have been greatly improved.

Recommendations

The paper by Mr. Blocksidge brings together the experience of mariners under the new régime and presents recommendations which he thinks will give the greatest chance of saving life in case of an accident at sea. In case of foreign-going passenger ships he offers the following recommendations: (a) Only such lifeboats to be carried as can be attached to or stowed immediately under davits at the ship's side. If necessary, further equipment to be installed in the form of buoyant apparatus that can be launched without lowering apparatus. (b) The abolition of open lifeboats without outside buoyancy and of wooden pontoon life boats unless fitted with internal air cases. (c) All lifeboats to be fitted with hand pumps. (d) The extended use of motor lifeboats fitted with wireless telegraphy. (e) Towing facilities to be provided. (f) Provision of emergency lighting apparatus. (g) Rope ladders secured and stowed at the ship's side. Other recommendations are made, but those quoted are sufficient to indicate the trend of the paper.

In the discussion of the paper attention was called to the difficulty of properly drilling enough of a ship's crew to handle the boats, and also to the fact that buoyant apparatus offered little shelter and was liable to be overcrowded and to capsize. Lifeboats that got away from ships, even if overloaded, usually saved their occupants.

Among the papers were two which give results of investigations and experiments, which received comparatively little attention because solid constructive work is not sensational; a long discussion of these papers may not be necessary because those who want to use the information will get it first hand.

Use of Tallows in Launching

The first of these two papers, by J. J. King-Salter, presented "Experiments on Tallows Used for Launching Ships." Only natural tallows or mixtures with commercial stearine were made. The author premises that there should be a layer of tallow on the standing ways, a thinner layer on the sliding ways and lubricant between. The tallow should stand up under load and stick to the ways, not forming the chief lubricant, but remaining intact after the launch. But such tallow cannot be recovered for future use, as remelting changes its properties. Lubricants used have been slurry, fish oil and soft soap; all tend to affect the tallow. The best lubricant proved to be soft soap mixed with a certain petroleum oil. Since the tallow must carry a considerable load only high-grade material should be used. The hardness can practically be controlled by the proportion of stearine and should be adjusted to the expected temperature at the time of the launching of the ship.

Balanced Rudders

The second paper of this group has a special interest in that Captain Maurice E. Denny took his bachelor's degree in naval architecture in this country. His paper is on "The Design of Balanced Rudders of the Spade Type." The paper presents a combination of computations, experiments on rudders attached to models in the trial tanks, and tests on shipboard. Only a few conclusions can be quoted here. They are: (a) the normal pressure increases at a less rate than the square of the speed; (b) going astern gives a larger torque than going ahead at the same speed, and even though the stern speed is less it is likely to determine the size of the rudder stock; (c) though final conclusions require tests on board ship, the methods of variations of torque are best investigated by aid of models. It seems hardly necessary to point out that computations of stress in the rudder stock involve bending and torsion. This paper gives authoritative information which is much needed, and which has hitherto been lacking.

Standardized Data for Airships

The last paper to be considered is one on the "Stanardization of Data for Airship Calculations," by H. B. Wyn-Evans, who defines the reasons for arriving at the standards used, illustrates their applications, and finally refers to some formulae for making direct comparisons between various classes of ships.

Owing to the effect of altitude on the engines, standardized trials are assumed to be at the altitude of 2,000 feet for rigid ships and 1,000 feet for non-rigid ships. There are four speeds usually quoted for airships: (1) maximum speed on trial; (2) normal full speed, being 0.9 of the foregoing; (3) cruising speed, 0.8; (4) comparison speed, defined as 40 knots. There are two methods of determining speed; (1) on a measured course, and (2) by aid of a Pitot tube surrounded by a stream-line body. Experiments tend to show that the layer of air affected by an airship is relatively thin and well defined.

The author of the paper claims that airships can now be designed and constructed with perfect confidence.

Free Zones in Ports

BY WALDON FAWCETT

Incident to the general revision of the tariff upon which the Congress of the United States is now engaged, there has come a sharp revival of interest in the proposal to establish and maintain foreign trade zones in ports of entry of the United States. The movement for the extension of American commerce and the ambition for the upbuilding of the American merchant marine have contributed to the agitation of the subject and shipowners and operators are directly as well as indirectly interested.

FOR some time past there have been pending in the national legislature bills designed to create in American ports what might properly be designated "neutral" zones. The Committee on Commerce of the United States Senate manifested considerable interest in the proposal coincident with the framing of the Merchant Marine Act of 1920 and such was the spirit of agreement between Republican and Democratic members that, for a time, it appeared that a favorable report on the measure would be forthcoming ere the adjournment of the 67th Congress. In the press of issues of more immediate insistence this question of policy was passed on to the present Congress.

If the creation of foreign trade zones would prove as beneficial as is claimed in stimulation of the business of the American merchant marine it is most unfortunate that the proposal is saddled with a name that creates instinctive prejudice. For the appropriate designation "foreign trade zones" is comparatively little used. Rather it is the fashion in the United States to refer to the prospective neutral areas as "free zones" or "free zones in ports." The word "free" is damning. Radical and rabid protectionists and the tireless protective tariff "lobby" at Washington have encouraged the idea that "free zone" is synonymous with free trade to such an extent that it is extremely difficult for the proposition to obtain a fair and unbiased hearing before Congress. That the project has made headway in the face of misconception and misrepresentation is strong evidence of the desire to invoke, in aid of American shipping, this instrumentality of international trade.

No less impartial an authority than the United States Tariff Commission has declared that the use of the word "free" in connection with "port" or "zone" is apt to be misleading, since the term has no relation either to port charges or to any policy of "free trade" or "protection," as these terms are commonly applied in the United States. Essentially, the foreign trade zone is an alternative and supplementary device for the system of bonded warehouses, bonded manufacturing warehouses and the entire drawback system with which the public is familiar. Particularly does the device promote transshipment in foreign trade, which circumstance establishes instantly its contact with the shipping interests.

Definition of Free Zone

A free port or free zone has been described as a place, limited in extent, that differs from adjacent territory in being exempt from the customs laws as affecting goods destined for re-export. In more detail, a free zone may be defined as an isolated, inclosed and policed area, in or adjacent to a port of entry, furnished with the necessary facilities for lading and unlading, for supplying fuel and ship's stores and for storage and reshipment. As regards customs duties there is in this reserved area, freedom and immunity, unless or until the imported goods enter the adjacent domestic market. Within the posted trade preserve goods may be landed, stored, mixed, blended, repacked, manufactured and reshipped without the payment of duties and without intervention by customs officials.

For the domestic trade of the United States the establishment of foreign trade zones would have no significance. Nor would the system be likely to either increase or diminish the volume of goods of foreign origin entering this country. But unquestionably the plan would lead to multiplication of the volume of international commerce that would "pass our way" and in equivalent proportion would it place an increased measure of carrying business within the reach of American shipowners. Frequently it would be advantageous if goods en route from one part of the world to another could tarry in the United States for conditioning or pending the relief of port conditions at ultimate destination, as, for example, in the case of the recent congestion at the port of Havana. Even more often would foreign goods be routed via the United States—preferably in American ships—if there were facilities whereby the alien wares could "wait over" and be combined with United States products destined for a common destination. Every service of this type would be feasible if neutral zones were in being.

Drawback System

While the nominated program of foreign trade zones has been hailed in some quarters as an innovation in so far as the United States is concerned, as a matter of fact the past policy of the United States has not been unfavorable to the form of commerce that the so-called free zone is designed to promote. Indeed, the drawback system which allows repayment of customs duties when goods are re-exported and the bonded warehouses which afford duty-free storage for goods intended for re-export exemplify in kind the basic principle of the neutral zone at a port of entry. It may well be asked in this connection why the instrumentalities mentioned do not serve all the practical purposes of a foreign trade zone. The answer is that the devices at hand have proven totally inadequate for the free flow of international commerce past our gates. Defects in the systems have been in part responsible but hardships have also been imposed upon traders by faulty forms of administration.

For example, recourse to the bonded storage warehouse can not aid in expediting the entry and clearance of shipping or the handling of merchandise because vessels must submit to the same formalities and requirements whether they bring dutiable goods or goods to be placed in bond, and the goods themselves, whatever their destination, must be valued, sampled, weighed and tested before removal from the dock. Much of the delay incident to the assessment of duties on imports for domestic consumption is equally imposed on goods destined to be reshipped. It is obvious that the practice and regulations governing the entry of dutiable goods en route should be of the utmost simplicity in the case of a ship landing part of its cargo at an American customs port and desiring to continue its voyage with the remainder of its cargo.

Restrictions on Handling

One of the worst features of the present bonded warehouse system is that the handling, sorting, mixing or repacking of goods is prohibited. Only where serious damage is threatened

can the original package be opened, and even then it must be done by special permission and under customs supervision. This limitation utterly defeats that consolidation of shipments which is so conducive to the prosperity of the American merchant marine. Even more stringent and hampering are the regulations which virtually nullify the usefulness of the bonded manufacturing warehouse. The drawback system, the third of the present devices, is excellent in theory but in practice it has been found anything but effective, principally, no doubt, because it is no more free than the other institutions from the delays and burdens incident to customs enforcement.

Illustrations almost innumerable might be cited to show how seriously and injuriously American shipowning and ship operating interests are affected by the inadequacy of the present bonding and drawback system. For one thing, American ships are deprived of what might otherwise be a profitable carrying trade, the transportation of rice from the Orient to Latin America. The rice milling industry of the United States is the most efficient in the world in point of special machinery and equipment and skilled labor but the mills are idle a considerable portion of each year because their sole function at present is to prepare the domestic product, which is limited in quantity. Rice from the Far East, en route to Central and South America and the West Indies, would come to the American plants for cleaning and milling were it not for the expense and formalities connected with the stop-over. The Oriental rice moves in full ships' cargoes, averaging about 6,000 tons, so that it is necessary to invoke the drawback system and the time-consuming red tape involved in this system has literally strangled the trade.

Consolidated Shipments

The Latin-American trade which, just now, beckons invitingly to American shipping interests is impeded no less by our present cumbersome bonded warehouse system than by the inelastic drawback system. Merchants in Latin America, particularly buyers of all classes of wearing apparel and articles of adornment, very much prefer to purchase from houses that will assemble the specialties that are requisitioned even though the selections represent the products of a number of different countries. To consolidate shipments in respect to the wishes of the Latin-American customer involves, therefore, sorting and repacking of the foreign wares that are to accompany the United States merchandise. This is virtually impossible under the present American bonding system which does not permit the original packages received from Europe to be broken and rearranged. To such a pass have matters come that it has been necessary on occasion to ship goods from the United States to a port in the West Indies to be there repacked and consolidated with European goods before continuing on to destination.

Transshipment Trade a Maritime Index

Loss to the United States of transshipment trade must appear, in the eyes of the average shipping man, the most serious indictment that can be drawn against our present bonding and drawback system. Such has been the growth of this phase of commerce that it is calculated that a normal, annual turnover of $4,000,000,000 is involved in the operations of the leading maritime nations in assembling, transshipment and redistribution of merchandise. As has been mentioned above, manufactured goods enter to some extent into this transshipment trade, but in the main it is concerned with the raw materials of those countries that have not attained a high stage of industrial development and that are dependent on the maritime nations for the transportation of their products and the supply of their necessities.

While the transshipment trade of other leading maritime nations has been expanding steadily to the obvious advantage of ship operators and merchants the transshipment trade of the United States has declined until it is of almost insignificant proportions. It is all too apparent that the scope and extent of a nation's transshipment trade is the measure of the virility of its maritime industry. The history of the past one hundred years shows most conclusively the tendency of ocean-borne commerce to concentrate at the so-called "free ports"—Hamburg, affording a conspicuous example—and lends force to the argument of those friends of the American merchant marine who contend that it can never realize its destiny unless foreign trade zones be created at leading United States ports.

Efficient Port Facilities

Scarcely less important to American shipowners than the greater number of cargoes that would be offered would be the improvement of United States port facilities that might be expected to follow the establishment of a system of free zones. It goes without saying that the most important prerequisites of a neutral port of the kind referred to comprise adequate and efficient modern facilities for the lading and unlading of cargoes, the entry and clearance of vessels and the handling of merchandise. Specialists who have, in behalf of the Tariff Commission and at the behest of Congress, made a study of the neutral zone proposition do not charge that the representative ports of the United States are lacking in wharves, docks, piers and terminal facilities. Rather is it their criticism that these physical facilities have, with few exceptions, developed by a process of planless accretion.

A remedy, it is claimed, would be provided under the influence of neutral port conditions. Up-to-date mechanical equipment for the speedy and economical handling of cargo, which has been lacking heretofore because there was not the traffic to keep it continuously and profitably employed, would be forthcoming, it is predicted, because the steady flow of commerce passing through a free zone would put an end to the erstwhile fluctuations between slackness and congestion. Similarly, it is forecast that capital would be attracted to port installations and equipment by the certainty of profitable return from the accelerated commercial movement that would result from the operation of the free zone system. In some quarters, misgivings have been voiced as to the effect of the establishment of a foreign trade zone in a United States port upon the existing investment in cargo-handling equipment and terminal facilities. Experts who have, at the behest of the United States Government, investigated this aspect of the situation at Copenhagen and other ports where the neutral zone plan has been subjected to the test of time, insist that there is absolutely no occasion for uneasiness on this score. It is declared that even at the trade centers where the provision of free zones has been characterized by the installation of elaborate equipment, publicly financed, the development of the business of the free zone has been accompanied by material increase in the use of the previously existing and privately-owned port facilities.

In reassurance to the interests who have capital invested in the present appointments of United States ports, it has been emphasized in the discussions at Washington that the purpose of a so-called free port is not to divert business from those that now transact it but to provide for new business that, under existing handicaps, has no opportunity to develop. As for the shipping interests, and, in sympathetic degree, the shipbuilding and ship outfitting interests of the country, it would appear that they have all to gain and nothing to lose by the establishment of neutral zones at strategic points, albeit the effect might be to cause some diversion of ocean traffic from present objectives.

SIMPLIFICATION OF ENTRY AND CLEARANCE

Foremost of the immediate boons to shipowners and operators of the installation of the neutral zone system would be the simplification of entry and clearance. Time lost by merchant vessels, whatever the cause, is always costly and one of the most perplexing responsibilities confronting vessel owners is that of so calculating normal or probable delays that will involve the idleness of the ship and crew as to maintain the requisite level of income and profit. Especially baffling in this process of forecasting lost motion has been the detail of figuring the delays that must logically be ascribed to customs procedure. It is a foregone conclusion that an allowance of this kind should be reckoned for every port of call but it is sheer guesswork whether the delay will be one of hours, or of days, duration.

Commenting on this particular phase of shipping operations and the possibility of correcting or reducing the evil via the instrumentality of free ports, an official of the United States Tariff Commission said that it is the free-lance operator of ships who suffers most severely from time-stealing customs procedure. Officials of regular steamship lines or operators of vessels that habitually traverse given trade routes are likely to acquire a familiarity with the regulations and administration in their particular environment that enable them to reduce to the minimum, say to terms of hours, the delay incident to entry and clearance. But the operators of tramp steamers and independent tonnage of all classes pay heavily in elapsed time for the technicalities or formalities of making entry and they are liable to pay in a double sense, if penalties are incurred through inadvertence or a failure to understand or correctly interpret the regulations. Within neutral zones entry and clearance formalities are reduced to a minimum with the object of allowing prompt docking, uninterrupted discharge of cargo, quick lading and an early clearance.

Equalization of inbound and outbound traffic is a promised blessing no less to be esteemed by the ship operator than the one above enumerated. The need of better balance of tonnage—the assurance to owners that they will find cargoes both in and out bound—has been one of the deficiencies that has held back the development of the American merchant marine and any panacea that promises to correct this is certainly worthy of attention. Peculiarly pertinent at this juncture, when so many of the nations of the world are engaged upon or have in prospect revisions of their tariff systems, is the contention that the inauguration of a system of neutral zones would free the transshipment trade from the unsettling effects of tariff changes. Shipping interests would, to a great extent, be spared that chill which strikes the industry whenever a new national tariff policy is in the making and the whole commercial atmosphere is charged with uncertainty in consequence.

What Are We Carrying?

BY "OLD SCOTCH"

It is the basic desire for increased comfort and luxury that is one of the main supports of traffic on the seas. The crude necessities for sustaining life are produced in almost every country in sufficient amounts to supply the local demands. In the whole progress of civilization the luxury of today becomes the necessity of tomorrow, hence we in America will become increasingly dependent upon our sea-borne commerce to dispose of our surplus of manufactured articles. In thirty years the value of our manufactured goods exported from our shores has increased from $403,737,000 *to* $5,349,327,000, *or over twelve-fold. It is therefore, so far as our merchant marine is concerned, of the greatest interest to discuss what we may expect to carry in our ships.*

THE basic reason for ships is the transportation of goods and persons from and to the various ports of the world, to accomplish the interchange of necessities to maintain our existence and gratify our desires for pleasure insofar as travel by sea is concerned. Primitive man needed but few things which were not produced in his immediate vicinity, but in the complex civilization of today our needs, real and imaginary, are so diversified that seemingly, at least, every nation produces something which every other nation thinks it needs. The basic needs of mankind are food, raiment and shelter, hence the commodities which fulfill these desires must naturally form the great bulk of international trade. The demand for luxuries and comforts, ever increasing in the human mind, tends to accelerate international trade, as the people of one community gradually learn of new means for gratifying these desires possessed by other and quite often distant communities.

We have so rapidly gone from an agricultural to a manufacturing country that our shipping facilities become more than ever vital to our national well-being. People generally buy food products because they have to have them. On the other hand, manufactured goods must be sold in the competitive markets of the world, and we must have our own means for selling. At the recent annual meeting of the United States Chamber of Commerce, Secretary Hoover made the emphatic statement that if we are to succeed in selling our manufactured goods abroad, we must have our own native-born salesmen. Coming from such an authentic source on world commerce, the sentiment was loudly applauded. He might have gone further along the same line and stated that back of the salesmen must be American ships manned by Americans.

THE TREND IN EXPORTS

American ingenuity and love of comfort and luxury will ever tend to produce articles for export when people abroad hear of the American standards of living. The cheap automobile, once a luxury and now a necessity in the daily life of the people, will probably always be a leading article of American export. The demand for our labor-saving agricultural instruments is constantly increasing, as farmers of other countries learn of the increased production and greater ease of operation by their use.

Unfortunately for shipping data most of our statistics on the subject of foreign commerce are given in dollars instead of tons. While money is the crux of our prosperity, shipowners must necessarily be greatly interested in the weights of commodities to be carried on the seas. As a matter of fact America is peculiarly fortunate in the matter of bulk cargoes.

Coal and petroleum probably form over half of all sea-borne traffic, when weight alone is considered. Up to very recent times two-thirds of all the petroleum in the world has been produced within our own borders, and 58 percent of all the actual coal reserves in the world are located in North America. Hence so long as these producers of power and comfort are demanded by mankind, America will for many years have a preponderating portion of these commodities to ship by sea. With two-thirds of the production of the world's supply of cotton within our own borders, that too will form an important item of sea-borne traffic.

Character of Imports

The return from the transportation of all these goods is what concerns shipowners most vitally. Our exports, consisting so largely of such bulky items as coal, oil and cotton, will probably always continue to exceed the weights of goods imported. Our imports will be less bulky but of more concentrated values. Hence a leading statistician has recently announced that an approximate method of determining the cost of our sea freights is to take 7 percent of the value of our exports and 3 percent of the value of the imports, which will be the financial returns to shipowners and operators. Last year the indirect returns for ocean freights to Great Britain, the leading maritime nation of the world, amounted to over $1,600,000,000. With our enormous volume of exports and imports, the monetary value of transporting our own goods in our own ships may well be imagined.

The lack of production in the war devastated European nations is keenly felt in our imports at the present time, and in all probability will continue for several years yet to come. Many American ships are returning to our ports in ballast as a direct result of this condition of affairs. In this connection it is interesting to note the inward manifests of ships now arriving at the port of New York, which are fairly indicative of our national import situation. We are so self-contained as a nation that a perusal of the various manifests will bear out my contention that luxuries instead of real necessities form a very important part of our sea traffic.

Luxuries From Abroad

A steamer arriving from Havre, France, brings in a cargo largely composed of such items as silks, trimming, ribbons, toys, musical instruments, perfumery, clocks, fancy cheeses, tulle, church ornaments, skins of animals, feathers, cigarette papers, embroidery, chinaware, medals and beads, jewels, fancy dresses, lingerie, pearls, etc., etc., most of which are to gratify the tastes of our American ladies, and which cost considerable money, but are not very bulky as ship cargoes go.

From Christiania, Norway, comes a ship laden with calfskins, fishhooks, sardines, safety matches, cheese, ammonium nitrate, etc., most of which could if necessity demanded be produced here.

From Antwerp an American ship arrived loaded with rags, brass ingots, wallpaper, books, aluminum sheets, etc., all of which does not indicate much production in plucky little Belgium.

From Piraeus, Greece, arrives a ship laden principally with olives, olive oil, figs and tobacco, and such miscellaneous items as camomile flowers, sage leaves and metallic money.

From the Bermuda Islands it is quite natural to find at this season of the year a cargo composed of potatoes, onions, celery and other kinds of spring vegetables. Owing to prevailing high rates on our railroads it is evidently cheaper to import from Bermuda by sea than to get these vegetables by rail from our own southern states.

From various Mexican ports a steamer arrived containing a cargo composed of bar lead, vanilla, coffee, quicksilver, sponges, sisal, pineapples, palm hats, goatskins, etc. Conditions are evidently not so bad in that revolution-distressed neighbor but what they can find some articles to sell to us in return for our foodstuffs and manufactured articles.

From Matanzas in Cuba comes an entire bulk cargo of sugar, which naturally forms one of our largest imports.

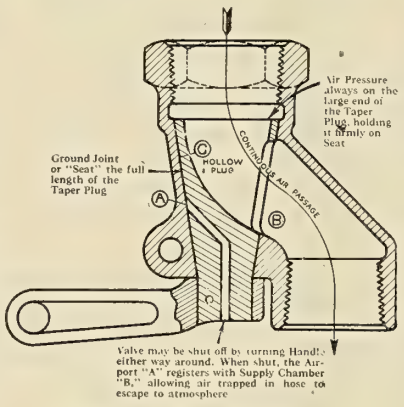
From Santos in Brazil an entire shipload of coffee is received to supply the insatiate demands of our American breakfast table. Incidentally it is claimed by importers, that only 10 percent of the enormous supply of coffee from Brazil arrives in American bottoms. Needing large quantities of our coal as they do in Brazil, it seems rather lax on our part that we do not utilize some of our idle Shipping Board tonnage to carry coal there and bring back coffee even if we do have to slash the rates to get our rightful share of this business.

Among the arrivals on this particular day was a single American wind-jammer loaded with a half million cocoanuts. For such cargoes as this it is a wonder that more American sailing vessels are not utilized. The high cost of operation of steam vessels and the comparatively low freight rates make sail propulsion look attractive, for as one prominent American schooner owner expresses it the only things a vessel uses which has not gone up in price are the trade winds and the gulf stream.

As we now have the ships of all descriptions to transact our foreign trade, we certainly need to make a study of all questions appertaining to trade and barter in order to keep our merchant marine busy and regain our national prosperity.

Cleco Pressure Seated Air Valve

THE Cleveland Pneumatic Tool Company, Cleveland, Ohio, has recently brought out an air valve designed to eliminate air losses through leakage in transmission. The object sought was to construct a valve in which the air could not come in contact with the seat, thus avoiding replacement of seats, and also to utilize the air pressure as a seating agent to hold the valve plug on its seat, thus eliminating packing, gaskets, stems and springs and reducing the valve parts to three, i.e., body, plug and handle.


Air Pressure always on the large end of the Taper Plug, holding it firmly on Seat
Ground Joint or "Seat" the full length of the Taper Plug
HOLLOW TAPER PLUG
CONTINUOUS AIR PASSAGE
A
B
C
Valve may be shut off by turning Handle either way around. When shut, the Airport "A" registers with Supply Chamber "B," allowing air trapped in hose to escape to atmosphere
Section of New Air Valve

This was accomplished by using a "hollow taper plug" with the large end uppermost; the air entering at the top, passing through and out of an opening in one side of the hollow plug into the supply chamber which connects directly with the air hose without the air coming in contact at any time with the valve seat, which is the outer wall of the plug as indicated by *C* on the drawing. The long arrow shows the direction of the air in its travel through the wide unobstructed air passage of the valve which is free from any angle turns to impede its progress. The short arrow indicates the point on the large end of the plug where the air pressure is constant, forcing the taper plug against the walls of the valve body.

The valve is provided with a unique waste arrangement to allow the accumulated pressure in the air hose to escape to atmosphere when the valve is shut off as shown by air ports *A* and *B* on the drawing: this is to safeguard the operator, who, when disconnecting the hose from the valve, often receives a gush of air in the face and accidently gets scale or grit in his eyes.

Problem of the Hull and Its Screw Propeller—III*

Cavitation—Phenomena that Actual Performance Data Have Shown to Occur With Various Types of Vessels

BY REAR-ADMIRAL C. W. DYSON, U. S. N.

IT has been shown how vessels can be divided into three general types according to the form of the after body lines. They may also be divided into types according to the values of the basic slips, namely:

1. Vessels having basic slips of the first order, which include vessels having basic slips of about 13 percent and lower.
2. Vessels having basic slips of the second order, which include all vessels having basic slips exceeding about 13 percent.

These distinctions according to the basic slips are encountered with vessels of type 2, and in order to explain them attention is called to Figs. 7 and 8 (see pages 400 and 402, May issue).

Cavitation (Fig. 8)

Many years ago, on the trials of the British destroyer *Daring*, difficulty was experienced in obtaining the contract speed due to failure of the propellers, such failure being accompanied by heavy vibration. The difficulty was finally overcome by increasing the projected area of the propellers to quite a large extent. After a thorough study of the phenomenon, Mr. S. W. Barnaby, of Thornycrofts, advanced the theory that the failure was due to a lack of flow of water to the propeller caused by insufficient supply head, this failure resulting in the formation of cavities in the water in which the propeller was working. He gave the name of cavitation to this action and fixed a limit of effective thrust, 11½ pounds per square inch of projected area, as that at which cavitation could be expected to occur. Later experience has demonstrated that this limit is not correct but that it depends upon the projected area ratio; the higher this ratio the higher the effective thrust before cavitation happens. Taylor supposes that both tip speed of the propeller and effective thrust enter into the solution of the problem. By inspection of Fig. 5, curves of design, it will be noted that tip speed increases with indicated thrust and with effective thrust as the projected area ratio increases. It is also a fact that, in changing from the basic conditions of resistance, for equal powers the indicated thrusts vary inversely as the tip speeds. Therefore with a vessel loaded down very heavily beyond the designed condition the tip speeds will, as a rule, be less than the designed tip speeds and yet, as experience has taught, cavitation may occur.

It is not the intention of this paper to advance any theories as to cavitation, but rather to have the student form his own theories after having had pointed out to him the various phenomena that actual performance data have shown to occur.

For convenience in discussion the phenomena encountered where the load fraction $\frac{e.h.p.}{E.H.P.}$ is less than unity will be spoken of as cavitation of or dispersal of the thrust column of the propeller, while for those phenomena met with where the load fraction exceeds unity the term cavitation of the suction column of the propeller will be employed.

Dispersal of the Thrust Column

It has already been stated that vessels can be divided into types according to the magnitude of their basic slips and that vessels of type 2 exhibit the variations due to changes in this magnitude.

Turn now to Fig. 7. Without cavitation it has already been pointed out that to obtain the value of the apparent slip for any other than basic conditions the equation is:

$$s = S \frac{I.H.P._a \times 10^{Z_s}}{I.H.P.},$$

or $\log s = \log S + \log K + Z_s - Z_p$, where Z_s is taken from curve 1.

With hulls of type 2 at any given value of load fraction there will be a corresponding value of speed fraction $\frac{v}{V}$, at which the quality of the wake will change materially; in the cases of vessels of type 2 having basic apparent slips of the first order two changes will occur and there will be two corresponding values of $v \div V$. The first change with such vessels will be from a basic slip of the first order to one of the second order, while the second change will be from slips of the second order to cavitating slips. The first change will occur without loss of efficiency of propulsion when the value of K equals unity. When the value of K is greater than unity the change of slips will be accompanied by an increase in value of K and all the phenomena of cavitation will occur. When K equals unity the second change will be accompanied by a rapid loss in efficiency of propulsion.

When the first change occurs, if it were known what the new basic S were to be, it could be inserted in the equation for apparent slip in place of the original basic S and the values of Z_s be taken from curve 1, Fig. 7, as before. In place of making this change of basic slip, available data have given the curve marked 2, from which, using the value of the original basic S, the new values of Z_s are taken. For this curve of Z_s the values of Z_s vary as $3.09 \log \left(\frac{V}{v}\right)$.

Now assuming that when the actual apparent slip at any gross load fraction has reached the value of the basic S apparent slip conditions are on the verge of change

$$\log s = \log S + Z_s - Z_p + \log K$$
$$s = S,$$
$$\therefore Z_s + \log K = Z_p.$$

Turn now to Fig. 8. The abscissas of this figure are values of load fraction $\frac{e.h.p.}{E.H.P.}$, while the ordinates are values of speed fraction $\frac{v}{V}$. The point whose abscissa value and ordinate value are both unity is the point of basic condition, while diagonals passing through the origin and crossing the ordinate $\frac{v}{V} = 1$, at any value of $\frac{e.h.p.}{E.H.P.}$ are diagonals of effective thrust ratios, the ratio being equal to the load fraction $\frac{e.h.p.}{E.H.P.}$ at which the diagonal intersects the ordinate $\frac{v}{V} = 1$, and is expressed by $\frac{e.t.}{E.T.}$, in which $e.t.$ is the actual effective thrust, while $E.T.$ is the basic thrust of the propeller.

* Paper read before the Society of Naval Architects and Marine Engineers, New York, November, 1920.

Lay down the curve where $Z_s = Z_p$, one of the points of which must be the point of basic condition, and it will be found that the curve marked A will follow the law—

$I.H.P._p$ or $S.H.P._p$ varies as 3.09 log $\left(\frac{v}{V}\right)$ or Z_p varies as 3.09 log $\left(\frac{V}{v}\right)$ which is the same as that for Z_s when $s = S$.

Calling the new basic slip of the second order, S_1, the ordinate of any point on A, $\frac{v}{V_1}$; the value of Z_s for $\frac{v}{V_1}$ taken from curve 1, Fig. 7, Z_{s1}; the original basic slip S the corresponding value of the ordinate $\frac{v}{V}$; and the value of Z_s for $\frac{v}{V}$, taken from curve 2, Fig. 7, Z_s,

$$\log S + Z_s = \log S_1 + Z_{s1},$$

from which for any assumed values of S_1, $\frac{v}{V_1}$ with its corresponding value of Z_{s1}, can be found a curve of values of S for a series of assumed values of $\frac{v}{V}$ (each less than $\frac{v}{V_1}$), with the corresponding values of Z_s. Taking a series of values of S_1 for any value of $\frac{v}{V_1}$, it will be found that as S_1 increases S will increase and $\frac{v}{V}$ diminish until S_1 equals approximately 21 percent, when the value of S will become constant for any further decrease of $\frac{v}{V}$.

The values of $\frac{v}{V}$ and the values of S at which the latter becomes constant are the limits at which the change from basic slips of the first order to those of the second order occurs, and this statement is borne out by all the data available. The curve of these slips is shown at the lower part of Fig. 8, while the limiting curve of $\frac{v}{V}$ is shown, marked B. For type 1 and type 3 vessels this shift of Z_s values does not occur, so far as can be ascertained, but Z_s is taken always from curve 1, Fig. 7. These two types and type 2 of first order of apparent slips having $K = 1$ pass on down to $\frac{v}{V}$ values shown by curves C, Fig. 8, before genuine dispersal of the thrust column, with consequent loss in efficiency, is encountered. These curves C have been determined from the performances of a four shaft vessel when steaming with only one propeller in use on each side of the ship, the idle propellers dragging, a slight correction having been allowed in the *e.h.p.* curve of the vessel for the increase in resistance due to these idle screws. The actual increase occurring is one that should be solved by the model tank.

Turning now to hulls of type 2 with basic apparent slips of the second order, only one change occurs in the slip conditions, and that is the change from slips of the second order to those of cavitation. These latter are augmented (similar to those of types 1, 3 and of 2 when original slips are of the first order, when $\frac{v}{V}$ is less than those of curves C, Fig. 8) on entering cavitation due to the increase in power demanded by the cavitating condition.

As the curve B is the change limit for slips given by the slip curve D, it is assumed that a corresponding change from slips of the second order to those of cavitation will occur at values of $\frac{v}{V}$ varying inversely as the ratios $\frac{1 - S \text{ of } B \text{ curve}}{1 - S \text{ of 2d order}}$ and by assuming different values of these slips of the second order curves of cavitation limits varying from $S = .27$ down to curve B have been laid down.

For hulls of type 2 curve B has been checked by the performances of submarines of the Holland type, while the curves for slips of the second order have been checked by submarines of the Lake type. These two types usually are radically different in the forms of hulls and in the arrangement of their propellers. Vessels of the Holland type require the use of the surface draft in obtaining the *S.B.C.*, while only one-half diameter of the hull is used in determining the ratio $2L.A.B. \div H$, and those of the Lake boats, while obtaining the *S.B.C.* in the same manner as for the former, use a much greater value than one-half diameter of hull in obtaining the after body length ratio; in fact, for both types the H in the ratio $2L.A.B. \div H$ equals the height of the point of the stern above the base line.

This results in a much greater value for the after body ratio of the Hollands than for the Lakes, with a corresponding reduction in the basic slip values. Due to the position of the propellers in relation to the hull and also to the peculiar form of hull, the Lake boats have a shifting value of K depending upon the length of the vessels until this length equals or exceeds 230 feet, when K becomes unity for all surface conditions of speed. For all lengths of vessels of the Holland type operating on the surface, K has a constant value of unity.

When vessels of either type are running submerged it becomes necessary to bring the diving rudders into operation in order to maintain proper balance, and the additional resistances introduced by the resistances of the diving rudders appear to vary with the speeds, disappearing entirely at 10 knots with boats of the Lake type, but reappearing at speeds above 10 knots. With vessels of the Holland type the re-

VALUES OF K FOR SUBMARINES

Lake Submerged

v	6	7	8	9	10	11	12
L.W.L.	K						
150	1.35	1.24	1.14	1.05	1.0	1.1	1.4
160	1.30	1.20	1.12	1.04	1.0	1.09	1.34
170	1.25	1.17	1.10	1.04	1.0	1.07	1.28
180	1.20	1.13	1.08	1.03	1.0	1.06	1.22
190	1.14	1.10	1.06	1.02	1.0	1.04	1.16
200	1.09	1.06	1.04	1.015	1.0	1.025	1.11
210	1.05	1.035	1.02	1.01	1.0	1.02	1.05
220	1.00	1.00	1.00	1.00	1.0	1.0	1.0
230	1	1	1	1	1	1	1
250	All below=unity up to 12 knots.						
260							
270							
280							
290							
300							

Lake—Surface

v	6	7	8	9	10	11	12	13	14	15	16	17
L.W.L.						K						
150	1.17	1.13	1.085	1.04	1.00	1.027	1.095	1.14	1.19	1.23	1.29	1.45
160	1.145	1.12	1.075	1.038	1.00	1.023	1.083	1.112	1.17	1.21	1.25	1.35
170	1.125	1.097	1.064	1.033	1.00	1.02	1.073	1.105	1.143	1.175	1.215	1.3
180	1.105	1.082	1.055	1.03	1.00	1.019	1.062	1.089	1.12	1.147	1.18	1.25
190	1.086	1.068	1.045	1.025	1.00	1.017	1.05	1.072	1.097	1.12	1.148	1.2
200	1.067	1.052	1.036	1.02	1.00	1.013	1.04	1.055	1.075	1.09	1.11	1.15
210	1.047	1.037	1.025	1.015	1.00	1.01	1.03	1.04	1.052	1.063	1.075	1.1
220	1.025	1.020	1.013	1.01	1.00	1.01	1.015	1.02	1.03	1.035	1.04	1.05
230	1	1	1	1	1	1	1	1	1	1	1	1
250												
270	All below = unity until $\frac{v}{\sqrt{L}} = 1.12$, when there may possibly occur a rapid increase in K, reaching 1.22 at $\frac{v}{\sqrt{L}} = 1.19$ and											
270												
280	rising rapidly.											
290												
300												

Holland Type
Submerged only as $K = 1$ for Surface

v	5	6	7	8	9	10	10.5	11
L.W.L.				K				
150	1.275	1.385	1.395	1.395	1.395	1.375	1.34	1.25
160	1.12	1.23	1.25	1.25	1.25	1.21	1.19	1.07
170	1.04	1.12	1.14	1.14	1.14	1.1	1.09	1.0
180	1.0	1.04	1.06	1.06	1.06	1.03	1.025	1.0
190	1.0	1.005	1.01	1.00	1.00	1.00	1.00	1.00
200	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

All greater lengths of L. W. L. have $K = 1$.

These K's are not true power augments, but are genuine variable changes in resistance, and therefore are not treated as the K in Problem 1 in the determination of cavitation.

sistance due to the influence of the diving rudders appears to reach a maximum at 7 knots, remaining practically constant in its effect on K until 9 knots is reached, when it begins to fall rapidly.

In both types of vessels the value K at any speed appears to depend upon the length of boat; in the case of the Holland boats K in the submerged condition becomes unity when a load waterline length of 200 feet has been reached, while with the Lake type the value of unity is not reached until a load water length of 230 feet has been attained.

These values of K for both types of vessels are given in the tables.

To illustrate the changes occurring with type 2 vessels with true $K = 1$, in passing first from slips of first order to slips of the second order and second from slips of the second order to cavitation, analyses of the performances of two vessels are given. The first vessel used is a Holland submarine having a basic slip of the first order, the problem being divided into two parts: (a) surface condition; (b) submerged condition:

VESSEL C

Hull

$L.L.W.L. = 268.57'$
$B = 22.16'$
$H = 14.16$ (surface)
$H_1 = \frac{B}{2} = 11.08'$
Nom. $B.C. = .459$
$\frac{B}{L.L.W.L.} = .0825$
$\frac{H}{B} = .684$
$L.A.B. = \frac{L.L.W.L.}{2}$
$\frac{2L.A.B.}{H_1} = 24.24$
$S.B.C. = .451$
$S = .125$
$K = 1$

Propeller

D ..... 7'
P ..... 6.25'
Blades 3
Projec. form. Standard
$\frac{P.A.}{D.A.}$ 4
$T.S.$ 8,520
$1 - S.$ ..... .875
V 20.91
$I.T._D$ 6
$I.H.P.$ ..... 4,879 (2 propellers)
$P.C.$ ..... .62
$E.H.P.$ 3,025
$S.H.P.$ 4,489

SURFACE PERFORMANCE

$\frac{\text{e. h. p.}}{\text{E.H.P.}}$	e. h. p.	v	$\frac{v}{V}$	Zp	K	S.H.P.d	Act S.H.P.d	Zs, curve 1, Fig. 7	S	s	Revs. Est.	Revs. Actual
.05	152	8.44	.404	—1.355	1	198		+1.043	.125	.0609	145.7	145
.075	228	9.57	.458	—1.1715	1	302		+.89	.125	.0654	166	166
.10	304	10.5	.502	—1.0414	1	408		+.77	.125	.0669	182.5	182.5
.15	456	11.86	.567	— .858	1	623		+.62	.125	.0723	207.3	207.5
.20	608	13.05	.624	— .7279	1	840		+.497	.125	.0735	228.4	228
.30	912	14.87	.711	— .5445	1	1281		+.335	.125	.0772	261.3	258.5
.40	1216	16.14	.772	— .4144	1	1729		+.233	.125	.0823	285.2	281.5
.50	1520	17.3	.827	— .3135	1	2181		+.154	.125	.0866	307.1	303.2
.60	1824	18.5	.885	— .231	1	2637		+.070	.125	.0863	328.3	328
.70	2128	19.36	.926	— .1613	1	3096		+.019	.125	.0901	345	347
.80	2432	20	.957	— .1009	1	3558		+.0	.125	.0991	359.9	363
.90	2736	20.5	.980	— .0477	1	4022		+.0	.125	.112	374.3	375

SUBMERGED CONDITION

$\frac{\text{e. h. p.}}{\text{E.H.P.}}$	e. h. p.	v	$\frac{v}{V}$	Z_p	K	S.H.P.$_d$	Act. S.H.P.$_d$	Z_s, curve 2, Fig. 7	S	s	Revs.	
											Est.	Actual
.025	76	5.05	.242	—1.667	1	96.7	105	+1.84	.125	.1862	100.6	102
.05	152	6.44	.308	—1.355	1	198.2	109	+1.575	.125	.2075	131.8	129
.075	228	7.33	.351	—1.1715	1	302.5	280	+1.4	.125	.2116	150.7	146
.10	304	8.06	.386	—1.0414	1	408	364	+1.275	.125	.2141	166.3	161
.15	456	9.26	.443	— .858	1	622.5	550	+1.09	.125	.2133	190.8	184
.20	608	10.26	.491	— .7279	1	840	750	+ .95	.125	.2085	210.2	203
.30	912	11.85	.567	— .5445	1	1281	1170	+ .76	.125	.2053	241.8	235.5
.40	1216	13.15	.629	— .4144	1	1729	1620	+ .622	.125	.2016	267.1	262

Unfortunately in the case of this vessel no measure of shaft horsepower on the surface was taken, the vessel being driven by Diesel engines. In the submerged condition electric motors were the propelling units. Attention is called to the extremely close agreement between estimated and actual revolutions, the slips not, as yet, having changed their character from those of the first to those of the second order. In the submerged condition the actual powers were obtained by measurements of electric input and voltage to the motors and the resulting kilowatts transformed to shaft horsepower by dividing by the factor .746. The estimated $S.H.P._d$ is seen to be somewhat in excess of the actual, and this excess estimate is accompanied by an excess in estimated revolutions over the actual. Should the actual measured power at the highest submerged speed be used in the calculation of revolutions for that speed the resulting estimated revolutions become 264.1 instead of 267.1.

The vessel just discussed has an after body of such form that it is almost at the dividing line between vessels of type 2 and type 1 and the character and quality of the wake are so good that there is no augment of power; that is, $K = 1$.

Should the vessel be one of type 2, slips of the first order, but with the character and quality of the wake such that K is in excess of unity, the performance becomes radically different. Upon entering cavitation the value of K becomes increased to approximately $K_c = 1.26\ K$.

Suppose in the case of such a vessel a series of performances be taken in which the net load fraction $\frac{e.h.p.}{E.H.P.}$ is constant but the speed fraction $\frac{v}{V}$ for this load fraction is decreasing due to progressive loading of the vessel, then

$$\log I.H.P._d = \log I.H.P. + \log K - Z_p.$$

Now let

$$Z_{pg} = Z_p - \log K,$$

that is, Z_{pg} is the gross load factor for the propeller when delivering the net load fraction $\frac{e.h.p.}{E.H.P.}$ with a power augment K. Call the gross load fraction $\frac{e.h.p._g}{E.H.P.}$.

When $\frac{v}{V}$ has decreased until it reaches the intersection of the ordinate at $\frac{e.h.p._g}{E.H.P.}$ with the cavitating curve of the basic slip S, of the first order, cavitation ensues and K changes value to $K_c = 1.26\ K$.

The equation for power then becomes

$$\log I.H.P._d = \log I.H.P. + \log K_c - Z_p.$$

As the value of $\frac{v}{V}$ still decreases, calling the value of the load factor corresponding to the point on the cavitation curve of S whose ordinate is $\frac{v}{V}$, Z_1, the equation for power becomes

$$\log I.H.P._d = \log I.H.P. + \log K_c - Z_p + Z_1 - Z_{pg},$$

but $Z_p - \log K_c = Z_{pg}$; therefore

$$\log I.H.P._d = \log I.H.P. - 2Z_{pg} + Z_1.$$

As in Problem A, the slip before cavitation equals $s = S \frac{I.H.P._d\ 10^{z_s}}{I.H.P.}$, where Z_s is taken from Curve 1, Fig. 7, but as soon as the cavitation curve of S is passed, while the equation remains the same, the value of Z_s must be taken from Curve 2, Fig. 7.

Turning now to the second vessel, which is of the Lake type, the range of apparent slips of the second order is entered. In the estimates of revolutions both in and out of cavitation the values of Z_s are taken from curve 1, Fig. 7, but in the estimates of power in the cavitation range a corrective factor must be introduced. Let this factor be called K_1. Its values are found as follows:

Turning to Fig. 8, attention is called to two points marked Z_p, one plotted on $\frac{e.h.p.}{E.H.P.} = .575$ and $\frac{v}{V} = .78$, while the other is on $\frac{e.h.p.}{E.H.P.} = .5$ and $\frac{v}{V} = .51$. Now for either of these points to find the value of K_1 take the value of $\frac{e.h.p.}{E.H.P.}$, called $\frac{e.h.p._1}{E.H.P.}$, where this same value of $\frac{v}{V}$ cuts the cavitating thrust curve for the basic slip S of the vessel. The Z_p value for this value of $\frac{e.h.p._1}{E.H.P.}$ call Z_1, then $K_1 = Z_1 - Z_p$ and

$$\log I.H.P._d = \log I.H.P. + \log K - 2Z_p + Z_1$$
$$\log S.H.P._d = \log S.H.P. + \log K - 2Z_p + Z_1$$

and by transposing the equation

$$Z_1 = \log S.H.P._d + 2Z_p - \log S.H.P. - \log K$$

is obtained, from which, when the actual power and load fraction are known, the cavitation loss can be closely approximated.

Also, by transposing, the equation

$$2Z_p = \log S.H.P. + \log K + Z_1 - \log S.H.P._d,$$

from which the load fraction $\frac{e.h.p.}{E.H.P.}$ corresponding to Z_p can be ascertained.

VESSEL D

Hull		Propeller	
$L.L.W.L.$	= 203.75′	Blades	3
B	= 19′	Shafts	2
H	= 16.1′	Form	Standard
H_1	= 15.1	D	6.17′
		P	5.542′
$\frac{B}{L.L.W.L.}$	= .093	$\frac{P.A.}{D.A.}$	.4
$\frac{H}{B}$	= .847	$T.S.$	8,530
		$1 - S$	.79
$L.A.B.$	= ½ $L.L.W.L.$	V	18.65
$2L.A.B. \div H_1$	= 13.5	$I.T._D$	6
Nom. $B.C.$	= .481	$I.H.P.$	3,830
$B.C.$ on $C - D$	= .35	$P.C.$	.62
		$E.H.P.$	2,371
$B.C.$ on $C - D$ cor. for $\frac{H}{B}$	= .52	$S.H.P.$	3,523
$S.B.C.$ on X	= .55		
S	= .225		

VESSEL E

Hull		Propeller	
$L.L.W.L.$	= 168′	Propellers	1
B	= 36′	Blades	4
H	= 11.46′	Form	Standard
$B \div L.L.W.L.$	= .214	D	9.5′
$H \div B$	= .318	P	11′
$L.A.B.$	= ½ $L.L.W.L.$		
$2L.A.B.$	= 14.66	Total $\frac{P.A.}{D.A.}$	.338
Nom. $B.C.$	= .482	$P.A. \div D.A.$	.2535
$K.B.C.$	= .65	$T.S.$	6,010
$B.C.$ on $A - B$	= .517	$1 - S$	.865
$B.C.$ on $A - B$ cor. for $\frac{H}{B}$	= .517	V	18.91
		$I.T._D$	2.8
$S.B.C.$ on W	= .646	$I.H.P.$	2,218
S	= .135	$P.C.$	.659
		$E.H.P.$	14.62

ANALYSIS

v = 13.17	$e.h.p.$ = 696	Z_p = .35	$I.H.P._d$ = 1,228
$\frac{v}{V}$ = .6965	$\frac{e.h.p.}{E.H.P.}$ = .4763	K = 1.25	Act. $I.H.P._d$ = 1,208
Z_s = .365			
s = .1727			
R_d = 146.5			
Act. R_d = 146.7			

This vessel also was not used in obtaining any of the design curves.

SURFACE CONDITION—ANALYSIS

v	e. h. p.	$\frac{\text{e. h. p.}}{\text{E. H. P.}}$	Z_p	K	S. H. P.$_d$		$\frac{v}{V}$	Z_s	S	s	Revs.	
					Est.	Act.					Est.	Act.
6	60	.0253	1.667	1.06	80.4	80	.3217	1.32	.225	.1073	122.9	.....
8	144	.05075	1.32	1.042	176	200	.4289	.975	.225	.1061	163.6	160.1
10	268	.1131	.98	1.0	369	370	.5361	.688	.225	.1149	206.6	203.4
12	444	.1873	.757	1.037	639	632	.6433	.46	.225	.1177	248.7	247
14	740	.3122	.522	1.068	1131	1134	.7506	.2784	.225	.1371	296.7	300.5
16	1050	.443	.362	1.10	1684	1670	.8578	.11	.225	.1386	339.6	345
17	1360	.574	.25	1.13	2239	2500	.9114	.035	.225	.155	367.9	362.5

The power data for the 17 knot point are doubtful, as there was no way of measuring it and the shop brake test power for the revolutions was used.

To illustrate the method to be followed in making an estimate of the effective horsepower delivered by a propeller when the $I.H.P._d$ or $S.H.P._d$ and the speed of the vessel are known,

SUBMERGED CONDITION

v	e. h. p.	$\frac{\text{e. h. p.}}{\text{E. H. P.}}$	Z_p	$\frac{v}{V}$	$\frac{\text{e. h. p.}_1}{\text{E. H. P.}}$	Z_1	K	S. H. P.$_d$		Z_s	S	s	Revs.	
								Est.	Act.				Est.	Act.
5	100	.04219	1.41	.2681	.05	.....	1.1	151	.....	1.55	.225	.3422	139	.....
6	140	.05512	1.31	.3217	.067	.....	1.08	186	.....	1.32	.225	.2482	145.9	.....
8	264	.1114	.983	.4289	.089	1.08	1.032	473	464	.975	.225	.2852	204.6	203.4
10	474	.20	.7279	.5361	.145	.87	1.00	914	896	.688	.225	.2846	255.6	253
12	774	.3265	.51	.6433	.255	.62	1.10	1543	1628	.46	.225	.2842	306.5	303.5

Neither of vessels A and B was employed in obtaining the curves of design, but, unfortunately, due to lack of reliable data, they both formed one of several vessels used in obtaining the values of K for their respective types.

Still another vessel, but this time of type 3, will be given as an illustration for that type.

the case of a vessel of a different type will be taken up in the next issue. In this case the hull will be of the Dreadnought type having a standard basic slip of approximately 13 percent. The vessel will be propelled by four 3-bladed propellers of standard form.

(To be continued.)

The Lubrication Problem on Shipboard

Oiling System Recommended by the Westinghouse Electric & Manufacturing Company for Geared Turbine Equipment

BY P. M. ROBINSON*

THE increasing use of high speed machinery for the development and transmission of power has brought with it the important problem of supplying adequate lubrication to the bearings and other moving parts in contact. In slow speed bearings (that is, under 50 feet per second rubbing velocity), the principal function of the oil is to interpose a film between the two rubbing surfaces to prevent metal to metal contact. However, in high speed bearings the amount of heat generated is more than can be dissipated by natural radiation; so that the oil must assume the additional function of carrying away the heat. To accomplish this purpose a considerable quantity of oil must be supplied; a quantity far in excess of the few drops per minute that are sufficient to keep a slow speed bearing operating satisfactorily. Therefore, to supply fresh oil continually would be out of the question. Instead the oil is drained away and saved to be used over again after having been restored to its original condition of temperature and purity. Thus there arises the necessity for a system to circulate and condition the lubricating medium.

The last few years have seen hundreds of vessels equipped with geared turbine-propelling machinery, a large proportion of which represent war orders placed by the United States Shipping Board Emergency Fleet Corporation. The oiling systems employed varied widely in character and makeup, depending largely upon the individual ideas of the shipbuilder or engine builder. Very often these systems proved inadequate, due somewhat to the severe operating conditions resulting from the war emergency and the inexperience of the operating engineers with the geared-turbine type of machinery; but also due to a large extent to the improper design of the oiling system itself.

Just at a time during the war when the greatest possible ship tonnage was needed, the Emergency Fleet Corporation was faced with the situation of having numerous vessels laid up with machinery trouble which, when analyzed, proved to be due very largely, either directly or indirectly, to faulty lubrication. Therefore a very thorough investigation was inaugurated by the Technical Division of the Corporation, which developed some very important information.

It was found that the systems in use were of two general types which could be designated as *gravity* systems and *pressure* systems. In a gravity system the oil is pumped from the drain tank into an overhead tank from which it is fed to the bearings by gravity, the tank being high enough to maintain the proper oil pressure. In a pressure system the oil is pumped from the drain tank and fed directly to the bearings under pressure from the pump.

Inherently the gravity system is the more reliable of the two, due to the fact that if the oil pump stops there will still be a few minutes' supply of oil in the gravity tank to keep the bearings lubricated until the spare pump can be started or the main machinery shut down. It was, therefore, logical for the Fleet Corporation to standardize on a gravity system and it is now considered the only system suitable for merchant vessels.

Some engineers are inclined to disagree with this conclusion and point to the navy, where pressure systems are the rule. However, on a naval vessel there are very good reasons for using a pressure system. On destroyers and light cruisers there is not head room enough available for installing a gravity tank, and on the larger ships it would mean placing the tank above the protective deck, which would be undesirable. However, on the other hand, naval vessels are operated full power only a small percentage of the time and the engine-room crews are much larger than in the case of merchant craft, which features offset the difference in latent reliability.

The Emergency Fleet Corporation developed a standardized oiling system which has proved very successful (see MARINE ENGINEERING, June, 1920, page 508). However, it is believed by the engineers of the Westinghouse Electric & Manufacturing Company that a few changes could be incorporated with advantage, and on all new equipments for privately owned vessels the Westinghouse Company is recommending a system as shown in Fig. 1.

WESTINGHOUSE OILING SYSTEM

The general layout of this recommended system indicates that there are included the following essential elements:

Gravity tank,
Drain tank,
Oil pump and duplicate auxiliary pump,
Oil cooler and duplicate auxiliary cooler,
Oil strainer,
Settling tank,
Oil purifier,
Reserve tanks.

The oil is fed by gravity from the gravity tank to the various bearings and gear sprays on the main propelling unit, from which it is drained into the sump or drain tank. From here the oil is pumped back to the gravity tank, passing on its way through the oil cooler and the strainer.

The arrangement is such that either pump may be used while the other is held as a standby. The speed of the pump is regulated by a float control device, located in the gravity tank, which maintains a constant level in the tank. The connection between the float and the pump may either be mechanical or the steampipe may be led up to the gravity tank so that the throttle can be immediately adjacent to the float. However, the mechanical connection is to be preferred, if a direct lead can be obtained. The level of the oil in the tank may be maintained high enough so that a slight excess is constantly running out through the overflow pipe leading back to the drain tank.

The oil coolers are so connected that either one may be used separately or both may be used together in parallel. Should both coolers be out of commission at once, a connection is available for by-passing them entirely. The valve in the by-pass line is of the spring loaded type, which may be held open by the hand wheel, or should an obstruction occur in the cooler, it would open against the spring, thus insuring a flow of oil at all times.

From the lowest point in the strainer box, gravity tank and reserve tanks there are pipes which lead to the settling tank, located just below. These pipes do not connect directly into the settling tank but are arranged to drain into a strainer funnel on the top of that tank, and they are so pivoted that either pipe may be swung out to discharge into a bucket or other receptacle for sampling purposes. It is recommended that enough oil be drained from the strainer box and gravity tank each day to prevent any accumulation of water or dirt. As soon as the clean oil begins to flow from the pipe it will be evident that enough has been drained. Steam coils are

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provided in the settling tank to hasten the settling process and to condition the oil for purification.

Just below the settling tank is located the purifier, which may be either of the centrifugal type or a filter. It should be operated each day long enough to take care of the dirty oil which has been drained into the settling tank. The purified oil is led back to the drain tank. At the end of each voyage all the oil in the system should be passed through the purifier.

Provision is made for filling from the deck either into the reserve tank or into the gravity tank. The filling pipe should be pivoted so that it can be swung out of the way when not in use. This precaution is made necessary by the possibility of water leaking through the deck-filling hole. As a further precaution against foreign matter the arrangement is such that no fresh oil can get into the bearings without first passing through the strainer. If the fresh oil is led into the reserve tank, it can only get into the system by passing down into the drain tank, from whence it would have to pass through the strainer on its way to the gravity tank. If the fresh oil is led into the gravity tank, the connection is such that it must pass through the strainer on its way.

A description of the various units for a 3,000 shaft horsepower installation is given below. For a larger job the units would be increased proportionately.

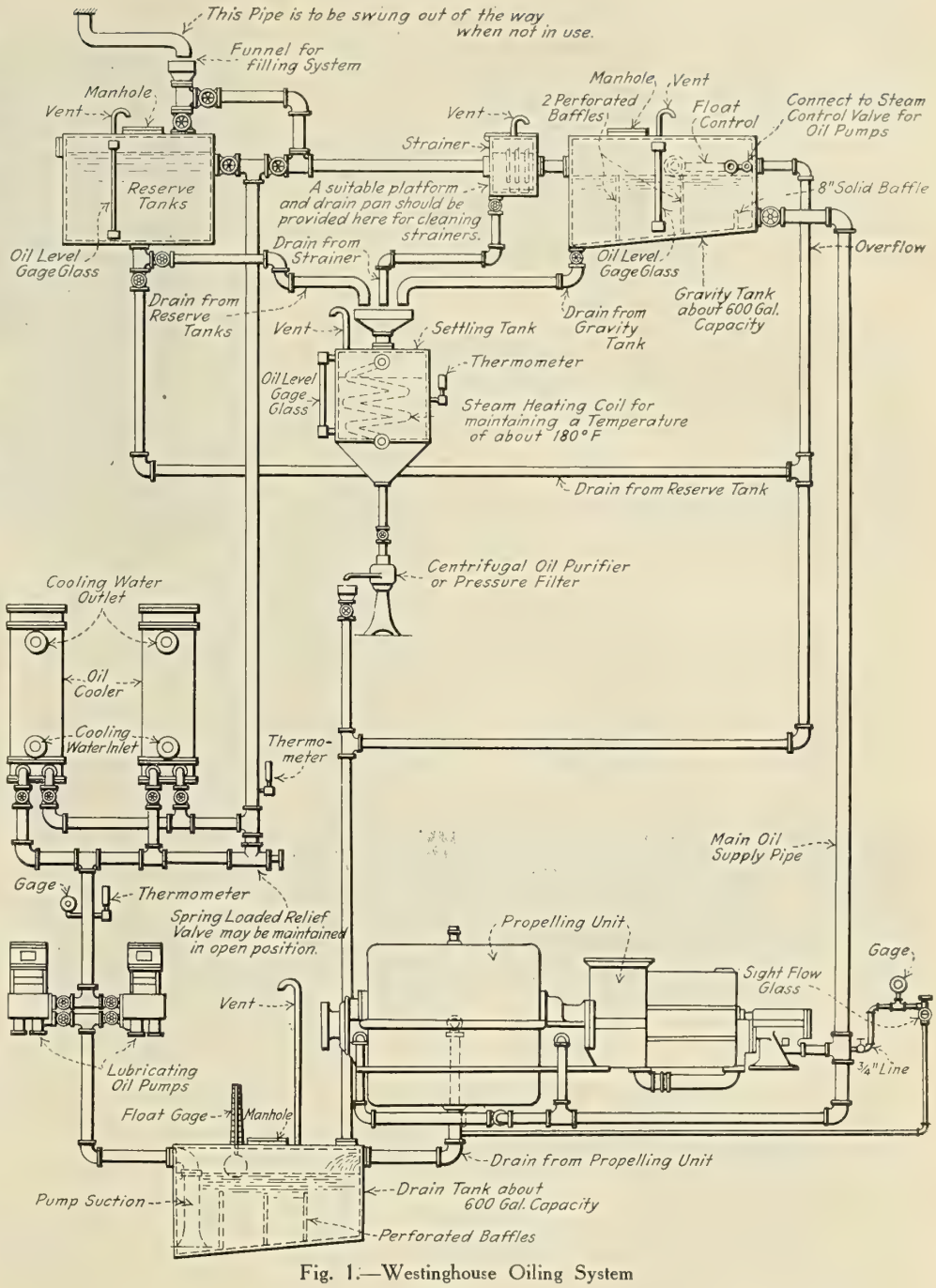

Fig. 1.—Westinghouse Oiling System

GRAVITY TANK

The gravity tank should be placed in the engine room hatch at a height that the distance from the centerline of the turbine to the bottom of the tank is not less than 20 feet nor more than 30 feet. The tank is rectangular in shape with a capacity of about 600 gallons up to the overflow pipe. Toward one end the bottom slopes gradually to a drain leading to the settling tank. The tank should be placed so that the bottom slope is fore and aft, and not athwartship.

The inlet connection to the tank is located slightly above the normal oil level so that any foam can be liberated on the surface.

The main supply pipe is led from the side or bottom of the tank at the shallow end, where a solid baffle plate extends across the tank to prevent any accumulation of dirt at the bottom of the tank from being carried over into the supply line.

A sufficient number of perforated baffle plates are installed to prevent excessive splashing of the oil due to the rolling of the ship.

The overflow pipe is led from the side of the tank several inches from the top so that the tank will never be absolutely full. It is desirable always to have a surface for the dissipation of foam.

A float control device of rugged character is included to regulate the speed of the oil pump and is connected thereto either by mechanical means or the steam pipe may be carried up to bring the throttle valve adjacent to the float. The former is to be preferred where a direct lead can be obtained.

The gravity also includes such accessories as a gage glass, a vent pipe and a manhole to allow cleaning.

DRAIN TANK

The drain tank should always be separate from the ship's structure to avoid any leakage of salt water into oil. It should have a capacity of about 600 gallons and should be located entirely below the level of the bottom of the gear case, so that there will always be a free drain from the gears. This is very essential so that any foam that may be churned up in the gear case can be carried away. For the same reason it is imperative that the drain pipe should enter the tank at or near the top so that the opening is never submerged.

The bottom of the tank should slope slightly in a fore and aft direction and the suction line should be located at the lowest point. This is fitted with a bell mouth close enough

to the bottom to prevent any accumulation of sediment or water. Since there is no provision made for getting rid of any such sediment in the drain tank, it is the best policy to allow none to collect. Ample provision is made above for cleaning the oil before it reaches the bearings.

Perforated baffle plates similar to those provided in the gravity tank should be included in the drain tank to prevent excessive splashing. There should also be fitted a vent pipe extending at least to the height of the centerline of the gear case, a float gage and a manhole for cleaning.

OIL PUMP

Two independent oil pumps are provided, each of which is of sufficient capacity alone to supply the entire quantity of oil used when running at a moderate speed, say 40 to 50 double strokes per minute. They are of the duplex type and should be located at as low a point as possible to reduce the suction head.

These pumps must of necessity be of the most rugged construction to secure the maximum reliability. Bronze valves and metallic packing should be used throughout since fibre packing has a tendency to disintegrate and get into the oiling system.

OIL COOLER

Two coolers are provided, each of which is of sufficient size to cause a temperature drop of at least 20 degrees F., when oil is circulated at the rate of about 175 gallons per minute and cooling water at 70 degrees F. is circulated at the same rate. The oil may either pass around the tubes or

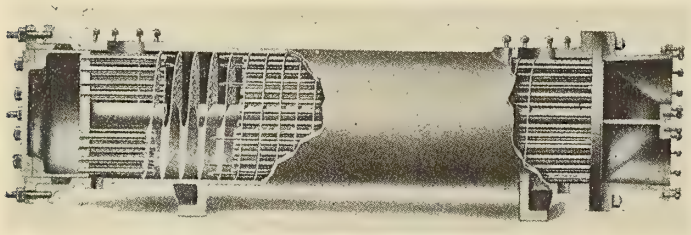

Fig. 2.—Typical Oil Cooler

through the tubes, according to the type of cooler used, but in general it should be so designed that the pressure drop on the oil is greater than the pressure drop on the water. In this way the pressure needed on the water side is less than that needed on the oil side, and care should be used to see that this condition is always maintained so that any leak will be from oil to water and not water to oil. To test for an oil leak a drain connection is provided on the cooling water discharge line, from which a sample can be drained at any time for examination. A typical cooler is illustrated in Fig. 2.

Circulating water is supplied by an independent pump with an auxiliary connection to the main circulating unit.

OIL STRAINER

There are two types of strainers, the duplex pressure strainer and the gravity strainer with flat vertical screens.

When a duplex strainer is used it should be placed on the discharge side of the pumps and never in the suction line. It is so arranged that one basket may be cleaned while the other is in operation, and when it becomes clogged the valves are shifted so that the oil passes through the clean basket.

The duplex strainer is inherently a dangerous element in the system. When the basket in operation becomes clogged, if the valves are not changed over immediately, either the flow of oil will be stopped or the basket will burst, allowing the accumulation of dirt, together with parts of the broken basket, to pass on into the system. To prevent this occurrence it is imperative that a by-pass be provided in which there is

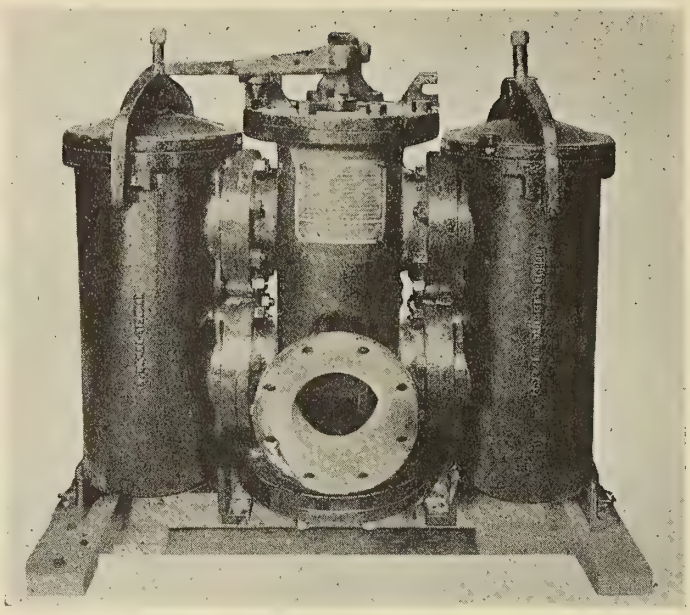

Fig. 3.—Duplex Pressure Strainer

a spring loaded-check valve, loaded to, say, five pounds, so that as soon as the strainer becomes choked the increase in pressure will permit the oil to by-pass and no interruption in the flow of oil will be experienced. An indicator showing the flow through this by-pass could be easily fitted to warn the operator that the strainer needed cleaning.

Fig. 3 shows the general appearance of this type of strainer.

The gravity type of strainer automatically eliminates the possibility of stoppage of oil by its construction, and since the oil flows through the screens by gravity alone it must necessarily be placed at the top of the system on a level with the gravity tank. Fig. 4 shows the construction of this type of strainer.

It consists of a rectangular box in which are placed three screens, through which the oil passes in succession. The first screen is sheet metal perforated with 1/16-inch holes. The second screen is wire gauze of 35 mesh to the inch. The third screen is wire gauze with a mesh of 70 to the inch. The screens fit tightly in the bottom and sides of the tank but do

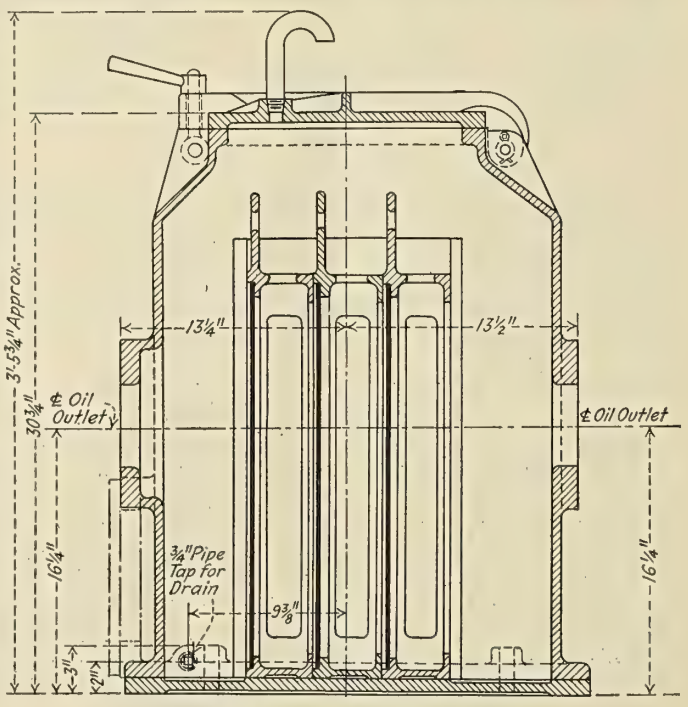

Fig. 4.—Section of Gravity Strainer

not reach to the top. The oil is not forced through the screens by any pressure from the pump but merely by a difference of the oil level on the two sides of the screens. As the screens become clogged this difference becomes greater until the oil finally flows over the top. When this condition is reached the screens should be cleaned, but the fact that they are not attended to immediately does not stop the flow of oil.

The screens can be readily cleaned without interrupting the operation of the system. By opening the cover of the strainer box each screen may be lifted out separately and thoroughly cleaned. At the bottom of each screen frame is provided a lip, which catches any dirt which may fall from the screen while it is being removed, thus preventing any of the accumulated dirt from returning to the system.

For cleaning the screens properly a suitable platform should be provided near the strainer box, where steam or air hose may be made available for easily doing the work. It will be found in a new installation, or in an installation where the machinery has been opened for inspection, that a considerable amount of dirt will be collected on the screens and it will be necessary for some hours at least after the oiling system is placed in operation that they be cleaned almost continuously. After this perhaps the cleaning can be reduced to once a watch or even once a day. Too much stress cannot be laid on the necessity of these being maintained clean, and it is on account of the lack of this precaution that some difficulties have been encountered.

From the bottom of the strainer box there is an open drain leading to the settling tank, which should be opened for a few minutes each watch to carry away any collected sediment or water.

Settling Tank

The settling tank is cylindrical in shape with conical bottom, having a capacity of about 600 gallons, and is provided with heating coils for preparing the oil for purification.

The drains from the strainer box, gravity tank and reserve tanks lead into an open strainer funnel on top of the settling tank and at the very bottom a discharge pipe leads to the oil purifier. There is also included a gage glass, a thermometer, a vent pipe and a manhole for cleaning.

Oil Purifier

For purifying the oil and getting rid of the water and foreign matter, there are two devices available. One is a centrifugal machine and the other is a filter, the first of which is probably to be preferred. A unit of not less than 100 gallons per hour capacity should be installed. The best results will be obtained by heating the oil to about 180 degrees F. before passing it into the purifier.

Fig. 5 shows the arrangement of a centrifugal purifier, while Fig. 6 illustrates the construction of a filter.

Reserve Tank

Reserve tanks of sufficient capacity should be provided to carry at least one full charge of fresh oil.

Oil Piping

Pipe sizes should be determined on the basis of about 175 gallons of oil flowing per minute at the following velocities:

Oil in drain return pipe from bearings and gear, not to exceed 80 feet per minute.

Oil in suction line, not to exceed 125 feet per minute.

Oil in supply lines and pump discharge not to exceed 250 feet per minute.

Connecting branches should be at least as large as the connections furnished on turbines and gears.

All piping should be fitted with flange joints and unions, so as to allow complete disassembling for cleaning without unscrewing any joints.

Thermometers are fitted in the inlet and discharge lines of the cooler. On the main supply line on a level with the turbine centerline is fitted a pressure gage and a flow indicator. And a pressure gage is fitted on the discharge line from the oil pump.

Quality of Oil

The oil should be a pure mineral oil, for if animal or vegetable oils be employed, they will saponify should any salt water come in contact with them, and there is furthermore the danger that they will turn acid with long use. The oil is at all times at a temperature of from 120 to 150 degrees F., which is in itself conducive to any chemical reaction should the necessary elements be present.

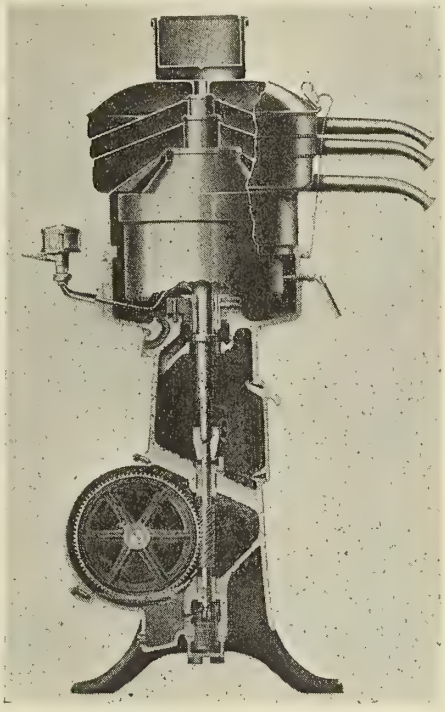

Fig. 5.—Centrifugal Purifier

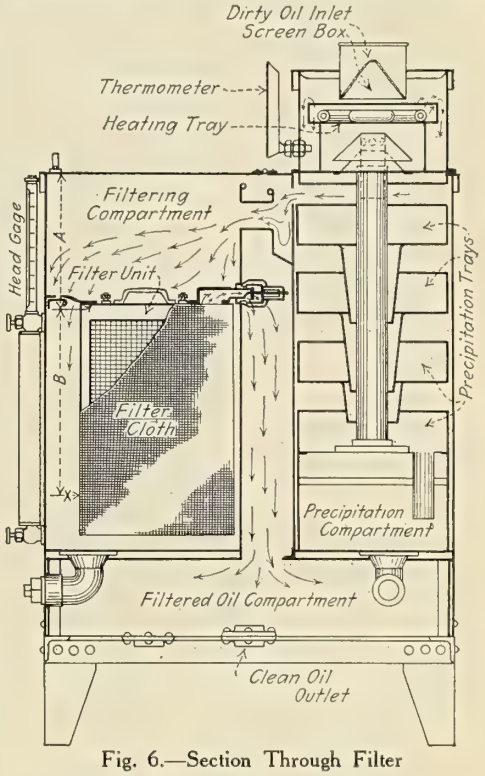

Fig. 6.—Section Through Filter

The choice of oil, so far as viscosity is concerned, is important. In the case of direct-connected installations, where no gears are employed, and, for instance, land installations where the turbines are directly connected to generators, a viscosity of 150 to 200 seconds Saybolt at 100 degrees is to be preferred, this low viscosity being chosen because, generally, lower viscosity oils are less subject to emulsification than those of higher viscosity. Furthermore, the journals are all of high speed and the bearing losses are smaller with the lower viscosity oil. Such an oil as this, however, is not suitable where gear teeth are to be lubricated, and for this purpose an oil of about 300 seconds Saybolt at 100 degrees is required, and in cases where the pinion or turbine bearing velocities do not exceed 70 feet per second, an oil as high as 500 seconds may be employed. The only effect of the higher viscosity oil on the turbine bearings will be that they will operate at a slightly higher temperature than if lower viscosity oils were employed, which need cause no concern whatever.

Any oil should have the paraffine, asphalt, or any other matter which may soldify, thoroughly expressed therefrom, as the matter may become separated from the oil, choking up the oil passages.

Oil should be selected, which, having the required viscosity, will have the least tendency to emulsify in the event of the accidental admixture of salt water.

Blended oils are to be avoided, for one kind of oil is more subject to emulsification than another; usually the one of higher viscosity being more liable to emulsification; so that with a blended oil, should any water become mixed with it, the heavier oil may go into emulsion, leaving the lighter oil behind, which perhaps may be of little value as a lubricant.

All bearing pedestals, reservoirs, etc., and all places where oil may collect, should be examined from time to time, to be sure that there is no accumulation of any solid matter. The piping comprising the system should be installed in such a way that it may be readily disassembled without unscrewing joints, as it is necessary that these be occasionally taken down and cleaned, the frequency of which operation, however, depends largely on the care of the oil in the manner outlined above.

Presumably at some period the charge of oil should be entirely replaced. No statement, however, can be made as to the length of this period. With the care outlined herein, it is believed that the life of the oil will be, as is experienced in land power stations, well nigh indefinite. Samples of the oil should, however, be taken from the system from time to time when in operation, and subjected to examination to determine that it has not deteriorated, plainly, and a new charge of oil should be subject to the same careful scrutiny as in the first instance.

Given a good lubricating oil system it is up to the operating engineer to see that it is properly handled, and under such conditions the geared turbine as a propelling unit has proven itself admirably reliable.

The Anshutz Self-Steering Compass

THE Anschütz gyro-compass, manufactured by Anschütz & Company, Neumühlen b. Kiel, Germany, has promoted the art of navigation enormously by virtue of two main features distinguishing it from the magnetic compass:

1. By its independence of all exterior magnetic or electric influence.
2. By the complete absence of lag or, in other words, by its steadiness in pointing true North.

The first advantage has made the *calculation* of the true course much easier and completely reliable. The second advantage gives an otherwise unattainable accuracy in *keeping a straight course.* The inner dial of the repeater-card allows one to read off the course with an exactness figured in tenths of degrees. The most insignificant yaw of the ship is at once stated by a movement of this inner dial, and that even more easily than if steering by land-marks. By aid of the Anschütz gyro-compass it is possible to steer even an unhandy ship, after a short experience, with an exactness of about 1.5 degrees.

Such an essential improvement of course-steering has suggested the idea of depending entirely upon the repeater to keep the ship on the actual course. The repeater is set in action by a comparatively great force. After a long line of experiments and practical experience, last of all on small, fast steaming boats, the steering of which was a very difficult task, the self-steering compass was developed, i.e., the Anschütz gyro-compass in mechanical connection with the steering-wheel of the telemotor of the rudder-engine.

The work of the helmsman, observing the compass-card and striving to neutralize every yaw by a corresponding turn of the steering wheel, is now done by an electro-motor controlled by the gyro-compass repeater motor. Like a good helmsman the self-steering compass causes a small turn of the wheel at a small yaw of the ship; the greater the yaw, the greater the turning of the wheel. Since the yaw is immediately followed by the turning of the wheel, without any loss of time, the rudder-engine is worked very little and the ship is nevertheless kept on a virtually straight course. In still water the steerage way seems to be drawn with a ruler. It is a matter of course, that with such a straight course a voyage can be made in a much shorter time with a corresponding saving of fuel. Not only are time and fuel saved but also the wages, food and subsistence of the helmsmen, whose mechanical and dull work is done by a most simple and reliable engine. The new little helmsman eliminates mistakes, he is at work day and night without fatigue and last but not least—he never gets drunk; in short, he is the most trustworthy little helmsman imaginable.

Mechanical Construction

In Fig. 1 the steering wheel of the telemotor is marked 1 and the self-steering compass 2. Both are joined by the link-

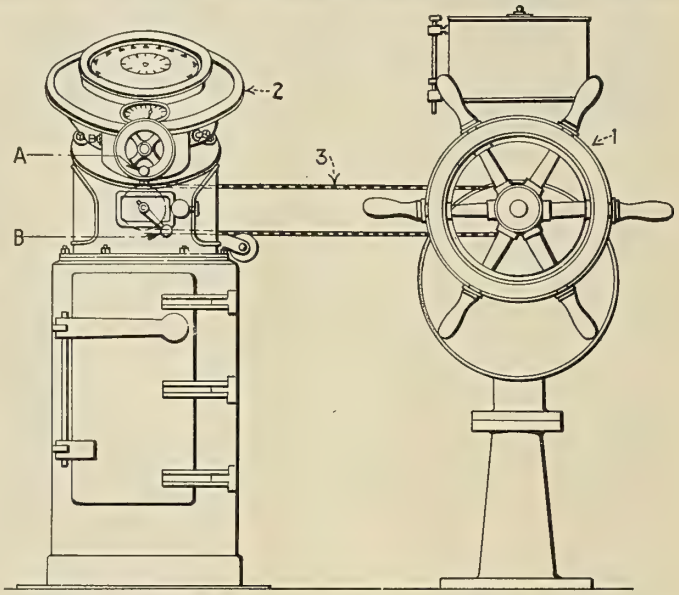

Fig. 1.—Self-Steering Compass and Steering Wheel of Telemotor

chain 3, running over a cog-wheel on the barrel of the steering-wheel. Both cog-wheels are always turning alike.

The compass card on the top of the apparatus is of the same type as in the usual Anschütz-repeater. The little dial underneath is the pointer of the helm recorder, recording the angle of the rudder. The hand wheel *A* serves to alter the course of the ship and the lever *B* is used for switching on or off the mechanical connection between self-steering compass and rudder engine.

Electrical Connection

The repeater of the self-steering compass is connected with the box containing the reversible motor of the Anschütz gyro-compass in the same way as are the other repeaters. By a little contact at the card an electro-motor is put into action starting the rudder engine at the smallest amount of yaw.

The motor contained in the lower part of the binnacle of the self-steering compass is energized by a suitable direct current circuit of the ship. The maximum load of this motor amounts to about 500 watts.

The brightness of the lamps illuminating the compass card from below can be regulated in three degrees by a step-switch.

Management

The handling of the self-steering compass is understood at a glance. Before starting it the indication of the card is checked by the master compass. The motor in the lower part of the binnacle is started turning over the lever *B* from "hand-steering" to "self-steering." This is done, when the pointer

of the helm recorder points to "midship position." From this moment the ship is steered automatically on the actual course.

An alteration of course is executed by the hand wheel *A*. Suppose the ship be running on a course of 82 degrees. A renewed calculation shows that the ship should stand on 86 degrees. In such case the circular division of the hand wheel *A* is turned to zero and then the handle of the wheel is turned four divisions to the left. That corresponds with an alteration of course of 4 degrees. By this manipulation the ship is at once brought round to a course of 86 degrees. All way-

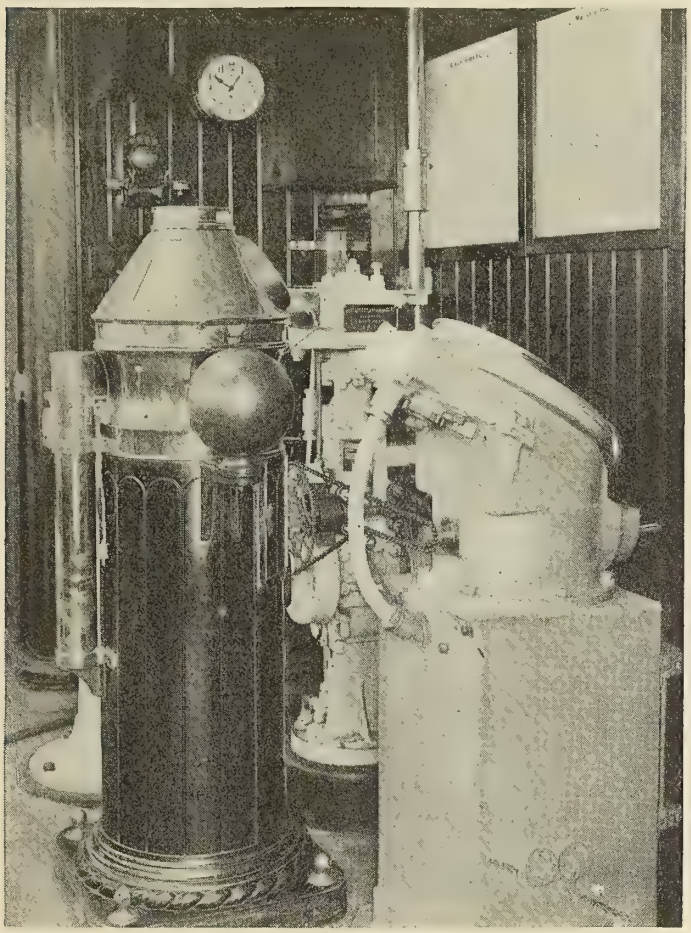

Fig. 2.—Chart House Installation

giving maneuvers are executed in the same simple manner by a turning of the hand wheel *A*. With the hand wheel loose, the ship will run straight on the actual course.

In case of emergency the steering wheel can be immediately employed. As soon as it is set free, the self-steering compass again takes the steering of the ship. At such intermediate application of the steering wheel one feels a somewhat increased resistance, which disappears when the lever *B* is turned from "self-steering" to "hand-steering." When hand-steering is desired, the lever is of course to be turned back to "self-steering."

The gyro-compass with its accessory instruments opens up unlimited possibilities of development. The Anschütz-course-recorder allows the coupling of the speed of the ship, recorded by a log of latest type, with the course, recorded by the gyro-compass. Thus the position of the ship is stated at every instant with the greatest exactness, without taking bearings and without calculations. The track-table of the course-recorder is registering and reproducing the path of the ship on a sea chart and permits the commander to control the execution of his commands. The admiral of a fleet is enabled to combine the maneuvers of all his ships on a true scale by aid of the registrations of the course-recorder of every ship. The course-recorder can be applied to many other purposes, but this shows sufficiently the increase of security and the savings of work and hands afforded by this new instrument.

Electricity Applied to Ship Auxiliaries*

BY H. L. HIBBARD†

IN all ship work reliability is of the first importance and electrical apparatus for ship auxiliaries must be ruggedly constructed, yet at the same time need not be clumsy. Furthermore, each piece of electrical apparatus should be particularly designed for the service and conditions to be met. These conditions need to be carefully *studied* and too great emphasis cannot be laid on this point, as it is at the root of the successful operation of electrical machinery.

Motors on deck will in many cases frequently be awash and hit by heavy seas, also, when the crew is washing down the deck, the hose will often play over the motors. Vessels trading in tropical climates will have deck machinery subject to the excessive heat of the tropical sun and all vessels on northern routes have their deck motors at times subjected to very low temperatures. In the engine room leaky steam pipes are a danger to the motors, and where Diesel engines are employed for the propelling machinery, thought should be given to the protection of motors and controllers from oil fumes and drippings.

Engine Room Auxiliaries

As an example of the engine room auxiliaries which are included in a large oil engine driven vessel, the following is a list of those supplied on one of our latest motorships, the *Cubore,* of 11,500 tons deadweight capacity:

Auxiliary	No.	H. P.	Location	Motors		Control	
				Type	Open or en.	Type	Open or en.
Fresh Water Pump	1	5	Floor	Hor.	Encl. Vent.	Mag.	Encl.
Turning Gear	1	20	"	"	"	Mult. Switch	"
Booster Compressor	1	25	Platform	Ver.	Open	Mag.	"
Refrigerator	2	5	"	Hor.	"	Hand Start	"
Oil Transfer Pump	1	3	Floor	"	Encl. Vent.	Mag.	"
Steering Gear	1	25	Steer Room	"	Encl.	Spec.	"
Circulating Pump	2	25	Floor	Hor.	Encl. Vent	Mag.	Encl.
Lubricating Oil Pump	1	7½	"	"	"	"	"
200-Ton Ballast Pump	1	15	"	"	"	"	"
Bilge Pump	1	15	"	Ver.	"	"	"
Air Compressor	2	125	Platform	"	Open	"	Open
500 Ton Ballast Pump	1	50	Floor	Hor.	Encl. Vent	"	Encl.
Lub. Oil Purifier	2	1	For'd Blk.	"	Encl.	Hand Start	Open
Fuel Oil Pump	2	3½	Floor	Hor.	Encl.	Mag.	Encl.
Sanitary Pump	1	7½	"	Hor.	Encl. Vent	Mag.	Encl.
Lathe	1	1½	Platform	"	Open	Mag.	Encl.
Grinder	1	3	"	"	"	Hand Star.	Open
Drill	1	2	"	"	Open	"	"
Generator	2	100 k w.	Floor	Oil engine driven			
Generator (Emergency Set)	1	100 k. w.	"	Geared steam turbine driven			

For a steam driven vessel many of the above auxiliaries will be similarly used in the engine room with the replacement of the several oil pumps and engine circulating water pumps by boiler feed, condenser, condensate pumps, etc.

The control for these engine room auxiliaries would be generally by the hand operated watertight panel or the push button watertight construction unless the centralized control were utilized.

* From a paper presented at a joint meeting of the New York Section of the American Institute of Electrical Engineers and the Metropolitan Section of the American Society of Mechanical Engineers, New York, January 28, 1921.

† Manager marine department, Cutler-Hammer Manufacturing Company, New York.

The auxiliary upon which probably more thought and study is being given at the present time from an electrical standpoint, than any other on shipboard, is the cargo deck winch. This is an especially important piece of machinery on a vessel handling miscellaneous cargo, and reliability of operation, and range of speed control in both hoisting and lowering, are of prime consideration.

Deck Machinery

Much discussion has been had of late with regard to the exact type of control to be furnished for deck winches and the results to be accomplished. One manufacturer is strongly advocating at the present time the electrically operated winch but provided with mechanical load lowering brake in place of the customary dynamic electric lowering control. While differences of opinion naturally exist on these details, one point is obvious; that the ideal electric winch is one which provides as nearly as practicable a straight horsepower curve, accommodating its speed automatically to the value of the load and permitting the handling of light and heavy loads without the necessity of changing gears; also that it gives in lowering as near as practicable, corresponding range of speeds for heavy and light loads down to the empty hook. And it must be borne in mind that time gained in the hoisting and lowering of the empty hook is that much clear gain in loading and unloading the vessel.

In the case of deck winch equipments and anchor windless as well, it is the practice to provide a mechanical brake on the motor shaft, electrically operated, to prevent falling of the load in case of failure of voltage.

Advantages of the Electric Drive

It has been shown by experience, that the electric drive of the auxiliary machinery has resulted in a considerable saving in fuel consumption of a vessel. And, also, the more efficient the propelling machinery, the greater the saving that may be obtained by the adoption of electric auxiliaries.

This is due to the fact that with steam driven auxiliaries, the exhust steam from the auxiliaries in the engine room is utilized principally for feed water heating. Where the total steam consumption, including propelling machinery, is heavy, a larger quantity of this exhaust steam can be efficiently utilized than where the total steam consumption is not as great. This applies only to such auxiliaries as are in constant use during the voyage. It is evident, therefore, that until the limit of feed water heating has been reached, the reduction in the steam consumption taken by the auxiliaries will not have nearly as great effect on the fuel consumption as would be the case after this critical point has been passed.

The above applies particularly to vessels using steam for their main propulsion. For ships operated by Diesel engines or Diesel electric drive, it is obviously of great advantage to operate all the engine room auxiliaries by electricity as it is largely a question of the efficiency of electric transmission with a large and reliable generating unit, against a number of small inefficient oil or steam engines, and it is naturally desired to avoid the generation of steam in any quantity on a motorship.

Aside from the engine room auxiliaries referred to above, attention is particularly drawn to the deck auxiliaries which are located some distance from the generating plant and where great losses would take place in the steam pipes feeding them. In these cases the electric drive is by far the most efficient method, irrespective of whether the vessel is steam or oil engine propelled. Some idea can be obtained of the loss of steam on the steam type of auxiliary when it is remembered that it is frequently considered essential to keep steam on the winch and windlass engines in cold weather to prevent the cylinders cracking or pipes bursting from freezing. The steam steering engine is a particularly noteworthy example of the wasteful use of steam as it is in effect only a steam ram taking steam full stroke with valves always left cracked a small amount.

The electric motor is always operating at a point of high efficiency and does not suffer in this respect from change of climatic conditions. Furthermore, the power transmitted through electric cables is practically a constant quantity regardless of temperature conditions, while steam transmission is affected very decidedly thereby.

The electric drive in addition to its convenience, adaptability and ease of operation, has the further merits of being available at any instant without preliminary warming up, or as above stated, the losses while standing idle with the steam plant.

Space, Weight and First Cost

Comparative figures which have been reliably obtained indicate generally some increase in the weight and space occupied for the electric over steam drive. In some cases however, such as the steering gear, an actual saving in space and weight is usually effected with the electric, and in other cases the difference is very slight. In the matter of first cost, it is also apparent from such figures as have been available to date, that electrical auxiliary machinery is roughly about 20 percent more expensive than steam, except in case of deck winches where the difference is more, sometimes 100 percent. It is also found that an oil engine propelled motorship is about 30 percent more expensive in first cost than a steam driven vessel and that, strange as it may seem, the Diesel electric propelled ship is slightly less expensive than the straight Diesel owing to the smaller and higher speed oil engines which it is possible to utilize.

As against these disadvantages of first cost and weight, are obtained the advantages of:

1. Suppression of heat in spaces adjacent to the gear and transmitting lines which is of importance in certain cases.
2. Elimination of accidents due to freezing and bursting of steam pipes, cylinders, etc.
3. The reduction of vibration and noise and an increase in the habitability of the ships due to these factors. This is particularly marked in the case of the steering gear.
4. The simplification and flexibility of control, operation being obtained readily from the most convenient point.
5. The obtaining of mechanisms as outlined above which are very much more efficient in operation than the steam equipments. This is the most important consideration.

Economy of Operation

That a very appreciable saving in the fuel consumption can be obtained by the use of electric drive is without question. According to an English writer, in modern equipment with propelling machinery consisting of double reduction geared turbines using superheated steam a saving of 8 to 10 percent of the fuel bill can undoubtedly be obtained by the adoption of electric drive on the auxiliary machinery.

Another important consideration is the fact that experience shows on motorships already constructed with electrical auxiliaries, that in port the power required during the period that the deck winches are handling the cargo is about three times the amount required with the auxiliaries at sea. Investigation of cargo handling vessels in general has shown, furthermore, that winches are idle five to eight times the amount of time they are in operation during an eight-hour day of work. With electric drive power is completely shut off while the winches are out of operation, but in the case of the steam equipments condensation and leakage continue the same.

While we have numerous general advices to the effect that the fuel consumption of steam driven auxiliaries is at least ten times that of electric, etc., we have some specific figures from oil engine driven vessels plying between Australian points and the Pacific Coast, which show a saving of approximately 25 percent in fuel consumption due to electric auxiliaries. Examination of the records of other ships shows a similar percentage gain.

The Fuel Problem for Steamships

BY LAWRENCE B. CHAPMAN

Although the burning of oil as fuel in marine installations has many advantages over coal, the rising cost and failing supply will undoubtedly limit its use within the next few years to naval and fast passenger vessels. The increased efficiency of coal firing by the possible adaptation of stokers to marine requirements, as well as the possible development of pulverized and colloidal fuels, may solve the problem in the future.

IN making a comparison between coal and fuel oil for use in steam generation on shipboard, the problem should be considered carefully from every angle, for there are many features connected with the use of fuel in oil burning vessels that have little or no influence in shore installations. Some of the points to consider are: Cost, weight, bunker space required, availability and future supply, adaptability.

Relative Costs of Fuels

In making a study of the costs of the two kinds of fuel, the comparison should be based on the amount of fuel necessary to produce equal amounts of steam under the same conditions of feed temperature and boiler pressure. In order to make this comparison, certain assumptions must be made regarding the heat content of the fuel and the boiler efficiency. The comparison will have to be of a general nature, for both these factors vary through a considerable range. Fair average figures for heat contents are 14,300 British thermal units per pound for coal and 18,800 British thermal units for fuel oil. The boiler efficiency when operating with coal has been assumed as 69 percent, and with fuel oil as 75 percent. These efficiencies are for operation under the best of conditions; trials will show higher values, but, generally speaking, efficiencies under working conditions will be lower. However, the figures given are comparable, regardless of whether or not they satisfy a particular case. The weight of oil has been taken as 7.75 pounds per gallon (58 pounds per cubic foot).

With the above figures, the ratio of heating value of a pound of oil to a pound of coal becomes:

$$\frac{18{,}800 \times 0.75}{14{,}300 \times 0.69} = 1.43.$$

The following table gives the costs of oil per gallon, per ton and per barrel over a wide range, together with the cost of coal per ton corrected to the same heat contents and boiler efficiency as fuel oil. Thus, if coal is $6.08 per ton, it would be just as cheap to buy fuel oil at $8.70 per ton ($.03 a gallon), as the same amount of steam could be raised in each case for the same fuel cost. In other words, one is getting more available British thermal units in a ton of oil than in a ton of coal and hence would be justified in paying a higher cost per ton for the former. Both prices are for the fuel in the bunkers.

Oil per Gallon, Cents	Oil per Ton	Oil per Barrel	Coal per Ton Corrected to Same British Thermal Units and Boiler Efficiency as Oil
3	$ 8.70	$1.26	$ 6.08
4	11.55	1.68	8.07
5	14.45	2.10	10.10
6	17.35	2.52	12.15
7	20.20	2.94	14.15
8	23.15	3.36	16.15
9	26.00	3.78	18.20
10	28.90	4.20	20.20
12	34.70	5.04	24.25

Walter M. McFarland has given the following rule: When the cost of coal in dollars per ton is double that of oil in cents per gallon, the fuel costs of producing steam are equal. He assumed, no doubt, slightly different boiler efficiencies and British thermal unit values, but the above table bears out the rule.

Causes of Fuel Price Fluctuations

Prices of fuel today are fluctuating so rapidly, depending upon labor and transportation conditions or whether the fuel is bought in the open market or on contract, that any exact comparison is useless. At the time of this writing fuel oil is selling from 8 to 10 cents per gallon in the open market (contract prices are much lower), against $15 to $17 per ton for bunker coal; so as far as immediate market prices are concerned, costs of producing steam are about the same for the two fuels. With the decreasing supply of fuel oil, the cost is bound to keep on rising while the high cost of coal is more or less a condition of labor and transportation.

The first cost of the oil installation with the piping, heaters, pumps, etc., is greater than that for coal. There is also a small amount of steam required (about 1½ percent of the boiler output) to operate the oil pumps and heat the fuel oil, which is also unfavorable to fuel oil. On the other hand, the engine room force for an oil burning ship would be cut down about 30 percent, which is an important item in operating expenses. The life of the boiler will be longer and the maintenance costs less for fuel oil than for coal.

Bunker Space

Fuel oil occupies about 40 cubic feet per ton against 50 cubic feet for coal. Thus oil requires about 80 percent of the bunker space necessary for coal. If this is corrected by the difference in heat content and boiler efficiency, we have:

$$0.80 \times \frac{0.69}{0.75} \times \frac{14{,}300}{18{,}800} = 56 \text{ percent.}$$

In other words, the amount of oil necessary to produce the same amount of steam under the same conditions occupies about 56 percent of the bunker space required for coal. In addition to this, liquid fuel can be stowed much more conveniently than coal, and the double bottom and other places not accessible for coal can be readily used for oil. How much of this saving in bunker space can be used for stowage of cargo depends to a large extent on the design of the ship. An actual layout would have to be made to get comparative figures. It is evident, however, that there will be a very large saving in space available for cargo.

Relative Weights of Fuels

A comparison of weights of the two fuels is decidedly in favor of the fuel oil. As already shown, the ratio of weight is

$$\frac{14{,}300 \times 0.69}{18{,}800 \times 0.75} = 0.70.$$

This shows that fuel oil to produce the same amount of steam as coal weighs only 70 percent as much as the coal, or the coal weighs 43 percent more than the fuel oil.

The saving in fuel weight gives the oil burning ship a larger net deadweight carrying capacity. This is also accompanied by an increase in hold space as previously pointed out.

For a slow ship on a short voyage the saving in bunker space and fuel weight, and to a considerable extent fuel costs, may not be very important. However, as the length of the voyage becomes greater or speed is increased, both of the factors become of more and more importance.

Fuel oil is much easier and cleaner to handle on shipboard, and much easier and quicker to put in the bunkers, and results in a much cleaner ship. The difference in comfort in the fireroom is beyond comparison.

Availability and Future Supply of Oil

From the above analysis it appears evident that with the present prices of fuel the only one to consider is fuel oil. Even with the price of oil higher per ton than coal, the factors of space, weight, reduced crew, and convenience of handling, would still give oil by far the advantage.

There are, however, two other factors of greater importance than those given. The first is the possibility of fueling an oil burning ship at the various ports of call, and the second and most important of all is the question of the future oil supply of the world.

Geologists of high rank tell us that at the present rate of consumption the world's supply of petroleum will be falling off rapidly in 10 or 15 years. With this rapidly decreasing supply of petroleum and the increasing demands for gasoline and fuel oil, the price of fuel oil is bound to rise rapidly. Another factor that will increase the price will be the demand of fuel for use in the Diesel engines of the world's growing fleet of motorships.

On account of the much smaller fuel consumption of the Diesel engine, the motorship will be able to operate long after the oil burning steamship has ceased to be an economical ship. A study of the table given at the opening of the article would lead to the conclusion that when oil reaches a value around 10 to 12 cents a gallon the coal burning ship would be more economical than the oil burning ship, especially if the price of coal is reduced due to improved labor and transportation conditions.

Steamship companies and many power plants on shore are today ordering and installing oil burning boilers and changing over existing installations from coal to oil burning. Even apartment houses and hotels are following in this wave of oil burning and are fitting oil burning equipment.

If we are to accept the figures of the geologists, it would seem that the present tendency with regard to fuel oil burning is not altogether in the right direction. Certainly, power plants and industrial installations on shore that are not affected by the weight and space requirements of a ship and to a considerable extent the boiler room and handling difficulties cannot long continue to use fuel oil.

Passenger ships and naval vessels can afford to use oil on account of its cleanliness and ease of handling long after cargo ships have found it uneconomical. For the present, and as long as fuel oil is available, ships requiring horsepowers not greater than 6,000 to 7,000 will prove far more economical with Diesel engines than with steam installations, as will be pointed out later. For the cargo carrying steamship and high powered passenger ship, it would seem that the proper solution is a return to coal fired boilers and the adoption of the mechanical stoker. The failing supply of fuel oil should be reserved entirely for naval vessels, medium powered passenger ships and Diesel engined motorships.

Mechanical Stokers

The mechanical stoker so far has been practically untried on shipboard, although it is giving excellent service in power plants on shore. The efficiency of a boiler fitted with a stoker is nearly the same as when using fuel oil. The steam necessary to operate the stoker would not greatly exceed the 1½ percent required for a fuel oil installation. Further, the labor expense certainly would be nearly as low as that for fuel oil. Stokers will involve some increased weight and space and the boilers will have to be raised. These factors, however, should cause no serious difficulties, especially with watertube boilers operated at the higher rates of combustion possible with mechanical stokers.

With improved bunkering facilities such as the Michener bunkering machine, much of the dirt and expense of bunkering could be eliminated. Mechanical conveyors could be installed for handling coal from the bunkers to the stoker, and mechanical bunker trimmers could also be used for trimming the coal in the bunkers. It is interesting to note that the methods of handling coal today on shipboard are practically the same that were used on the first coal burning steamship.

Comparative tests have been made on shore with the Emergency Fleet Corporation's four pass watertube boiler, both hand fired and with underfeed stokers. At a rate of combustion of 20 pounds of dry coal per square foot of grate surface the efficiency based on dry coal was roughly 71.5 percent for the hand fired boiler and 75 percent when fitted with mechanical stokers.

Mechanical stokers certainly have much in their favor and deserve more study and trials on shipboard than they have so far received.

Diesel Engines

This paper on fuel would not be complete without some mention of the Diesel engined motorship. The motorship is rapidly replacing the cargo steamship of 15,000 tons deadweight and under and will probably in the near future completely supersede it. This is, of course, due to the small fuel consumption of the Diesel engine, although the machinery weights and first costs are greater for the motorship.

Allowing a fuel consumption for the Diesel engine of 0.40 pound per shaft horsepower per hour, and for the oil burning steamship of 1.00 pound per shaft horsepower per hour, which is more than favorable to the Diesel ship, the fuel ratio becomes $\frac{1.00}{0.40} = 2.5$. The coal burning ship (hand fired) would have a consumption of 1.43 pounds per shaft horsepower per hour, if we use the same values of British thermal units and boiler efficiency as before.

These figures give the following results:

1. Fuel for a motorship weighs about 28 percent of that for a coal burning steamship and 40 percent of that of an oil burning steamship.

2. Fuel for a motorship occupies 22½ percent of the bunker space required for a coal burning steamship and 40 percent of that of an oil burning steamship.

When we stop to consider that the fuel for a coal burning steamship weighs 3.6 times and occupies 4.5 times the space that the fuel for a Diesel engined motorship does, we at once realize the tremendous saving in fuel cost and weight, and bunker space for the motorship.

A more complete comparison of the steamship and motorship will be given in a later paper.

Possible Fuels of the Future

In this comparison we have considered only the existing fuels and have made no allowance for the possibility of new kinds of fuel and new methods of burning fuel. A few of these possibilties should receive attention.

The first of these is pulverized coal which today is being adopted in many land installations and bids fair to be one of the most important fuels of the future. The lower grades of coal can be used for pulverizing and the cost of pulverizing and delivery to the boiler does not appear to be excessive. The danger of explosion, it is claimed, has practically been eliminated, so this former objection is apparently not pertinent today. It is handled in much the same manner as liquid fuel, is very flexible and gives as high a boiler efficiency as

fuel oil. Operating expenses, including crushing, drying, pulverizing, maintenance and depreciation of equipment, etc., are claimed to be less than with mechanical stoker installations.

Whether this fuel can be used satisfactorily on shipboard is questionable. On account of the large volume occupied by pulverized coal, it is not feasible to carry it in pulverized form in the bunkers. This would necessitate, then, a crushing, drying and pulverizing plant on shipboard which would require additional space, weight and added complications. While the fuel has attractive features for stationary plants and is bound to be widely adopted in place of hand firing and mechanical stokers, it probably will not be introduced on shipboard until more compact methods of crushing and pulverizing the coal have been devised.

Another new type of fuel that appears very attractive for use on shipboard is colloidal fuel. This fuel is a stable liquid fuel which consists of a mixture of pulverized coal and liquid hydro-carbons, about 40 percent coal by weight.

Colloidal fuel has been tried under boilers and has shown as good a boiler efficiency as fuel oil and can be used with the regular oil burning equipment.

An interesting article on colloidal fuel by L. W. Bates appeared in the *National Marine* for July, 1920, from which I will quote:

"One may summarize the situation regarding colloidal fuel as follows: It may be made with the smaller sizes of coals too fine to be fired on grates. Thus earth crushed anthracite and washings from rivers may be utilized. A patented process of ash removal permits the use of large and poor culm banks. Lump sizes of coal are not required, as the wastes and dust when pulverized are equally useful. It is the most compact fuel known. Whereas oil contains about 148,000 British thermal units per gallon, an average grade of colloidal fuel, made with bituminous coals, contains 160,000 British thermal units and grades may be made containing over 180,000 British thermal units per gallon. The liquid used in colloidal fuel may be a blend of several oils and may include the tars. In colloidal fuel 20 percent of such tar or 30 percent of water gas tar combined with pulverized coal may be stabilized in mineral oils. In regard to cost, colloidal fuel can compete with straight oil when the cost of oil is over 2 cents a gallon and coal at its usual prices. With oil at 10 cents and tar at 5 cents per gallon and coal wastes at $3 per ton, straight oil is 50 percent dearer than colloidal fuel made with the above materials. Since colloidal fuel is heavier than water, it will sink in it and so may be stored under water seal and thus made fireproof. A fire consuming the fuel may be quenched with water."

It certainly seems that the possibilities of this new fuel are very great, especially in those countries that have no oil, as a liquid fuel can be produced, 50 percent oil and 50 percent pulverized coal.

Future developments may bring new fuels and find ways of producing fuel oil such as from shale and the low temperature distillation of coal. Colloidal fuel mentioned above suggests one new and important development. Barring these developments, however, it appears that the day of the coal burning steamship has not passed. For the immediate future all ships requiring less than 6,000 shaft horsepower should be fitted with Diesel engines. While the fuel oil is available at a reasonable price, low powered cargo and passenger ships using steam machinery will be unable to compete with the motorship.

JAMES ROWLAND BIBBINS has been made manager of the newly created department of transportation and communication of the Chamber of Commerce of the United States. Mr. Bibbins was educated in Baltimore City College and at the University of Michigan. He has had wide experience in consulting work dealing with transportation problems in many cities throughout the United States and Canada; he has studied terminal and transit problems in New York, Chicago and other large American cities, and is especially qualified to deal with the problems confronting this new department.

Geared Marine Turbines*

BY C. R. WALLER†

THE first geared turbine used for ship propulsion was built in England in 1909 and installed on the S. S. *Vespasian*. Previous to this, reduction gears had been used for many years in connection with high-speed turbines driving electrical machinery, as well as centrifugal pumps and blowers. The first marine-geared turbine built in this country was produced in 1911, and from that time on hundreds of equipments have been made and installed on board different types of vessels.

When judging the merits of a propelling unit, it must be considered in reference to reliability, economy of operation, and economy of installation.

RELIABILITY

Of the several hundred geared marine turbines built during the last few years there has been considerable trouble, chiefly with the reduction gears. It has been stated on many occasions that most of these troubles have been due to the fact that the equipment was built during war conditions and that material and workmanship were not up to par.

While some of the failures may have been due to conditions caused by the war, there are numerous failures due to other reasons. Trouble with gear reductions has not been universal; many have not given trouble, showing conclusively that the failure of a great many gears must have been due to the design. This is unquestionably true when we consider that some of the latest designs are considerably different from the early designs.

With the experience gained by the different companies producing marine gears, I feel confident that most of their early gear troubles will be eliminated and that we can look forward to future designs that will be entirely reliable in their operation.

ECONOMY OF OPERATION

The geared turbine of the latest design is unquestionably the most economical propelling unit built. There is a very slight difference between the economy that can be obtained with a turbine on board a vessel as compared with land turbines; and with the present development in boiler designs, there is no reason why we should not look forward to having ships operated with as high economy as some of our modern power plants on shore.

The main loss between the turbine and the propeller is, of course, the gear reduction in connection with geared turbines and the generator and motor losses in connection with electric drive. The efficiency of a good gear reduction can be conservatively given as 98½ percent for the single-gear reduction and 97 percent for the double-gear reduction, whereas the equivalent efficiency of the electric drive will be 93 percent. For ships like tramp vessels going under full power from port to port, this difference in economy is of course important.

ECONOMY OF INSTALLATION

Under this heading should be considered the first cost of the equipment, as well as the weight and space occupied by the equipment. The geared turbine is a cheaper equipment than the electrical equipment and it can safely be stated that the electric drive for marine propulsion for an average size freight vessel would cost about 20 percent more than a similar equipment of the geared turbine drive. The weight of the electric drive equipment would be approximately 12 to 15 tons above that of the geared turbine drive.

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* From a lecture delivered before the Ocean Marine Engineers' Beneficial Association No. 80, New York, March 15, 1921.

† De Laval Steam Turbine Company, Trenton, N. J.

Motorship Building in Europe Increases

BY OUR SPECIAL LONDON CORRESPODENT

While it would not be correct to say that the development of motorship building has remained unaffected by the general shipping and shipbuilding depression, there is no doubt that European shipowners are much more inclined to proceed with the construction of internal combustion engined vessels than steamers. This is borne out by the fact that, while large numbers of steamships have been cancelled and work on many others slowed down, in practically every case shipbuilders have orders to proceed as rapidly as possible with the completion of motorships.

LLOYD'S returns for the quarter ended March 31 show that at the end of that period there were actually more motorships building than at the end of December, 1920, whereas the number of steamers under construction had diminished. In Europe there are now 194 motor vessels actually being built with a gross tonnage of over 500,000, in addition to which many more have been definitely contracted for and will be laid down in the near future. Of this number Great Britain is responsible for 66 totalling 263,180 gross tons, showing that in motorship building British shipbuilders are anxious to play a leading part.

What is perhaps more important from the technical standpoint is the number of new types of engines which are being built and the large amount of experimental work now being carried out. This is all the more significant in view of the fact that almost without exception Diesel engine builders have adopted standardization so that they would not interfere with their normal design, unless they see some great advantage is likely to accrue.

A good instance of this is shown in connection with the North British Diesel Engine Works, whose latest engine has just been completed and will be referred to later. Although in the meantime standardizing a four cycle type they are very actively engaged in experimenting with double acting two stroke motors which they look upon as the ultimate solution of the marine motor problem. They are now building their first experimental set of this type, and it is believed that it will mark a great advance upon existing practice. In particular they believe they have overcome one of the main objections to the double acting engine (which is to be found in the Blohm and Voss design, by providing for the admission of fuel in the center of the cylinder in spite of the obstacle of the piston rod. Blohm and Voss in their latest engine have reverted to the idea originally adopted by Krupps in employing two piston

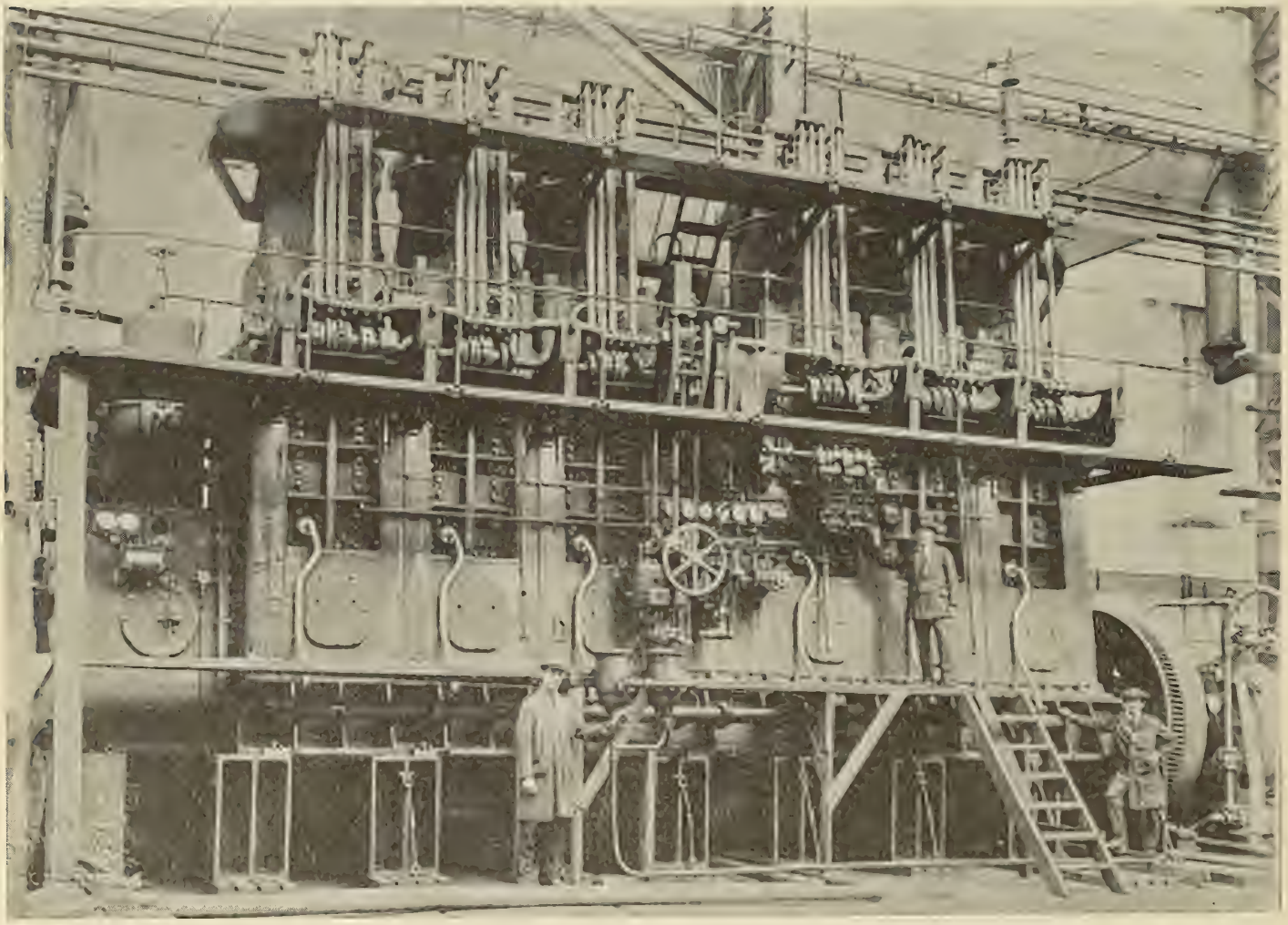

Fig. 1.—One of 1,600 Indicated Horsepower Harland & Wolff Engines for Installation in Motorship *Lobos*, With Electric Motor for Reversing

rods with fuel valves between them. It must be admitted that this seems a somewhat clumsy means and must necessarily add to the expense of construction.

LONG STROKE ENGINES FOR SINGLE SCREW SHIPS

Harland and Wolff, who have based the organization of their remarkable works at Glasgow on the policy of building only two types of standard Diesel engine, have also gone on somewhat new lines and are now constructing their first long stroke motor, intended for installation in single screw cargo ships. Hitherto all vessels constructed by this firm have been twin screw craft and the new development is mainly due to a demand on the part of shipowners for single screw vessels which naturally are somewhat cheaper to build and less expensive to run. It is not likely that Harland and Wolff will break away from their standard practice, but they realize that the single screw vessel represents a demand that must be met. This long stroke engine is mainly remarkable for its slow speed, running at about 85 revolutions per minute, and having a cylinder with a stroke approximately twice the bore. In other features it will be similar in design to the higher speed type.

The same builders are also departing from standard practice in a minor matter and are now offering shipowners a Diesel engine in which the reversing gear is actuated from an electric motor instead of a compressed air engine. One of the engines in which this new arrangement is adopted is illustrated in Fig. 1, showing the starboard set installed in the new motorship *Lobos,* for the Pacific Steam Navigation Company. The method of drive can be noted from this reproduction, the vertical electric motor being indicated in the center of the engine and replacing the vertical air and oil cylinders which are usually fitted.

This electric motor gives the reversing mechanism the necessary movement and the principle of operation remains unaltered. The cost of the electric system is rather higher than the normal design, but some shipowners prefer it on account of the fact that it is independent of the pressure of the air supply. One objection to the air system is that, if the air pressure is lowered, due to frequent maneuvering having taken place, the time of reversal is increased in a progressive manner so that just at the period when quick reversal is required it becomes slower and slower. Naturally this should not happen, if the engineers are on the alert and do not let the air pressure drop, but one cannot always guarantee that this will be the case.

A STEAM-OIL ENGINE

A further important technical development in connection with marine oil engine design remains to be recorded. This is that the Still combined steam and oil engine has now reached a commercial stage and Scotts Shipbuilding and Engineering Company, the licensees for the construction of this unusual type, have decided as a result of nearly a year's experimental work to proceed with the manufacture of Still engines, for installation in motorships. Their experimental engine, shown in Fig. 2, is a single cylinder set and the engines that will now be built will be of exactly the same design, but with six cyclinders instead of one, developing about 2,100 brake horsepower at 120 revolutions per minute.

The engine that Scotts have built is an ordinary two cycle Diesel motor, with the lower half of the cylinder below the piston acting as a steam engine. The steam is raised from the cylinder jackets and the exhaust gases, the circulating water being kept at about 400 degrees F. At this temperature it circulates around a boiler, steam being given off at about 120 pounds per square inch, and delivered to the under side of the pistons; thus adding a certain amount to the power developed. This is indicated by the fact that the cylinder which develops 350 brake horsepower has a diameter of only 22 inches and a stroke of 36 inches. The fuel consumption is stated to be 0.35 to 0.37 pound per brake horsepower hour, which is, of course, a good deal lower than any other type of Diesel engine on the market.

The Still motor is complicated by the addition of the steam plant, and it would seem that it must be more costly to build than an ordinary Diesel installation. However, there appears to be some doubt on this point and the builders claim that if everything is included there is not much difference, since steam is in any case required for operating the auxiliaries. The engine starts and reverses on compressed air, so that the ordinary Diesel reversing and starting gear is eliminated. The installation of the first Still engine in a large ship will be watched with interest and the fact that

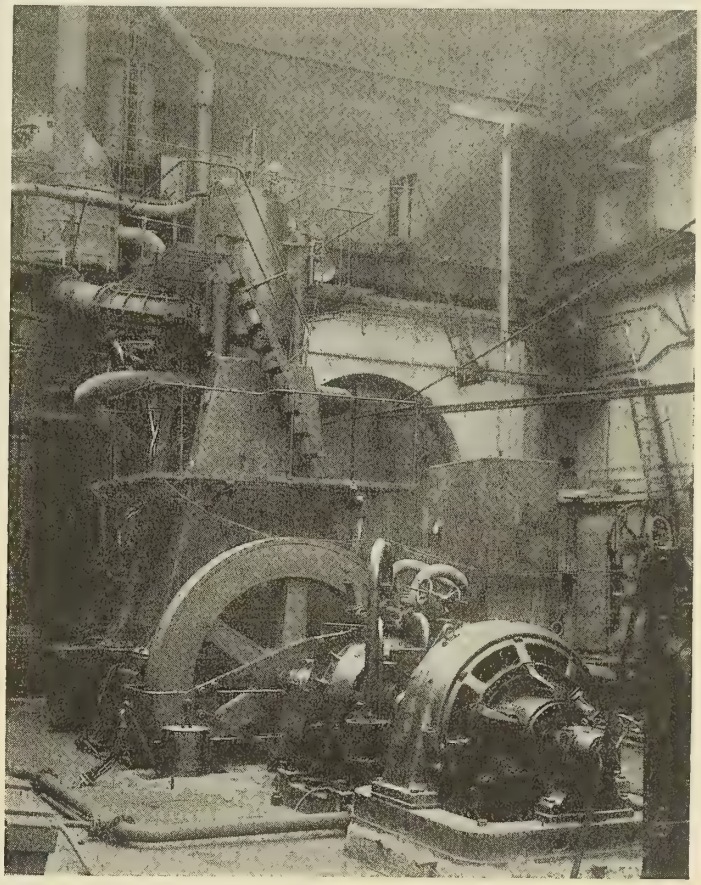

Fig. 2.—350 Brake-Horsepower Still Combined Steam and Oil Engine

such well-known shipbuilders as Scotts Shipbuilding and Engineering Company have taken up the construction will augur well for its future.

NEW MACHINERY FOR PASSENGER LINER

Although we have had to wait a long time for the first motor passenger liner to make its appearance, it will now probably not be long before it is completed. The twin screw machinery is being installed in the motor passenger liner *Domala,* for the British India Steam Navigation Company, and shipowners and shipbuilders are watching this ship with the very greatest interest, as it is realized that a great deal depends upon its satisfactory operation.

The two engines, of which an illustration is given in Fig. 3 showing them on the test bed, have been built at the new factory of the North British Diesel Engine Works, Ltd., Glasgow, and are of their own design. They are of the four cycle type, having eight cylinders 26½ inches diameter and 47 inches stroke, developing 2,300 indicated horsepower at 96 revolutions per minute.

Although they are of new design, there is nothing very unusual in their construction except for the fact that the air compressors are separately driven and that a novel method

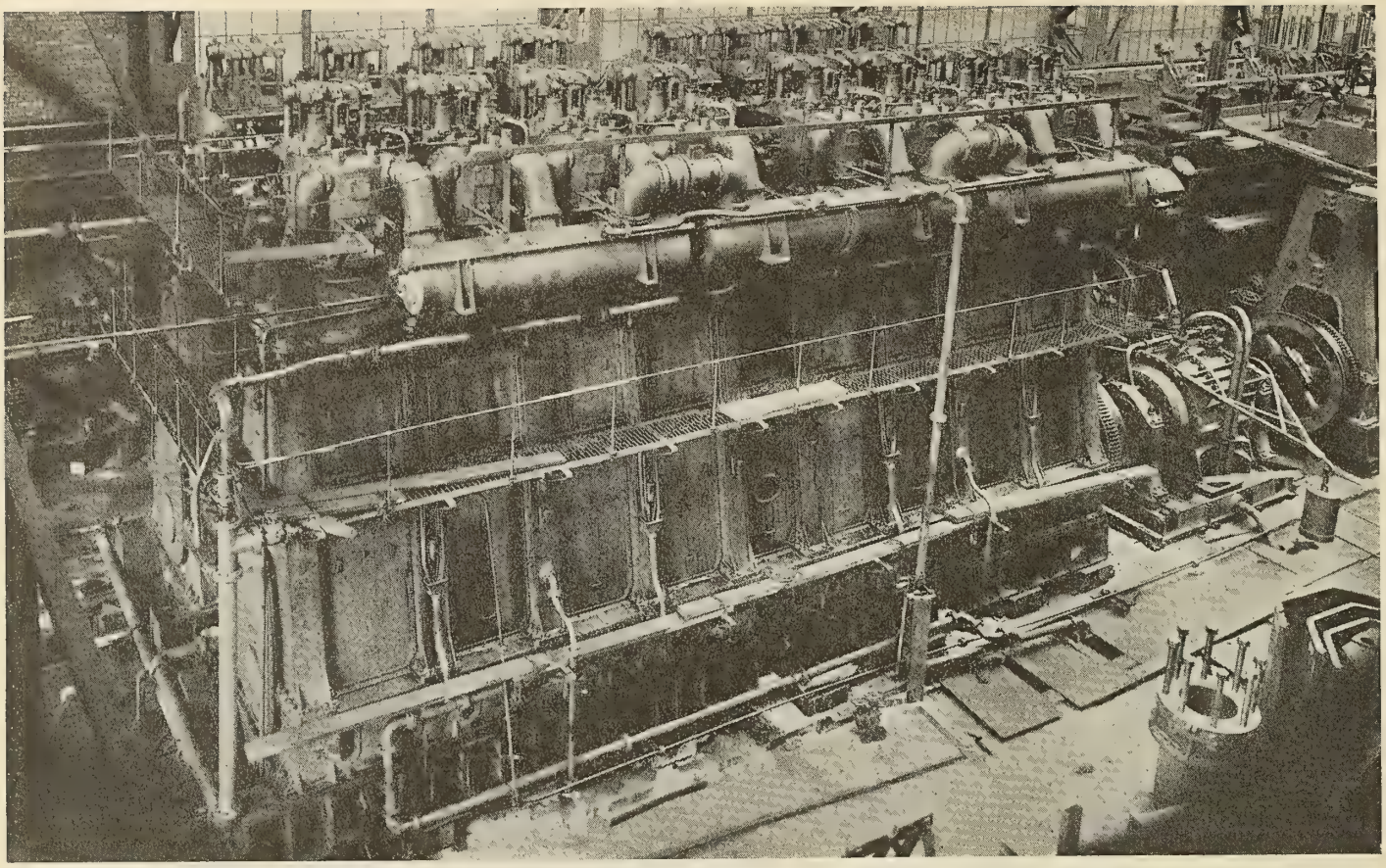

Fig. 3.—Twin Screw 4,660 Indicated Horsepower Machinery of the Motor Passenger Liner *Domala*

of reversing has been effected by lowering the whole camshaft before giving it the usual longitudinal movement to bring the astern cams into operation. This system, however, was probably employed mainly to avoid infringing any existing patent and on the whole does not appeal quite so much to the engineering mind as the more common arrangement of raising the valve levers above the camshaft before the latter is moved. Probably it would be difficult to improve on the Burmeister and Wain principle in this direction, and as it is understood that the patent for it has run out, possibly many manufacturers will adopt it as their standard.

In the motor passenger ship *Domala,* the injection and starting air compressors will be driven by separate Diesel engines, each developing 400 brake horsepower, and as two 300 brake horsepower Diesel driven generating sets are also fitted in the engine room, it will be understood that a very large amount of machinery is required. It is perhaps not surprising that the owners in their second ship have decided to fit the injection air compressors on the main engine, thus eliminating part of the auxiliary plant.

New Orders for Motorships

It is significant that Continental shipowners (even Scandinavians) are now coming to Great Britain for their ships and none of these shows signs of curtailing its programme in view of the present position. For instance, the Transatlantic Steamship Company of Gothenburg has announced a programme of six motorships to be delivered within the next two-and-a-half years; three of these are to be built in a British shipyard and are to have Doxford Diesel engines. The Holland American Line is having two 14,000-ton motorships built by Harland and Wolff, while several motorships are being constructed in British yards for Norwegian shipowners. Briefly it may be said that in spite of all detrimental influences, the future of motor shipping never looked more hopeful than it does at the present time.

The Volund Heavy Oil Engine

ALTHOUGH comparatively new in this country, the Volund heavy oil engine has had many years of successful operation in Europe. It is built in Copenhagen, Denmark, by the Volund Company, and handled in the United States by the MacBee Company, New York. The engine is of the two stroke cycle, valveless, crank case compression, trunk piston type. The cylinder is of special cylinder steel cast as a unit with its water jacket. The trunk piston is fitted with five piston rings at the top for tightness, and one near the bottom to retain and distribute the lubricating oil on the cylinder walls, and is linked to the connecting rod by a case-hardened piston pin, ground to finish. The crank shaft is made from a single forging, in one piece, with complete crank disks and counterweights. Mounted on each cylinder is a mechanical forced feed lubricator, which provides positive lubrication for the cylinder and for each of the bearings.

The sizes in which Volund engines are constructed range from a single cylinder engine developing 5 horsepower at 550 revolutions per minute to a six cylinder engine which develoopes 480 horsepower at 220 revolutions per minute. For marine use, the engine is fitted with a limit governor, to prevent racing of the propeller; the stationary types have inertia governors, which give close regulation for electric generation and other power purposes.

Special Ignition Features

While the engine is generally said to be of the surface ignition type, an examination of its construction and operation will show that the ignition is not a pure surface ignition. The hot bulb is a complete oval, with the upper part exposed to the atmosphere, while the lower part, contrary to common practice, is exposed to the compression space in the top of the cylinder. This lower face is pierced by a small opening. With combustion beginning in the bulb and completed in the

entire space, the lower walls of the bulb are heated very intensely. The combination of the high temperature of this wall, and the small size of the opening, results in a strong heating effect on the air passing through the opening during compression. Added to this, compression itself raises the temperature of the air, so that a temperature of about 1,100 degrees F. is reached within the bulb before the fuel is injected. This makes the ignition of the fuel take place from the temperature of the air, just as in the pure Diesel engine, although the high temperature is attained by different means. Ignition occurs before the fuel has time to reach the hot surface. As soon as combustion has begun, the expansion of the gases within the bulb causes a violent discharge of the burning materials into the top of the cylinder, which gives thorough and quick mixing, and complete combustion, resulting in economy of fuel and smokeless exhaust.

For starting, the blow lamp does not heat the hot bulb, but only a small ignition tube, which causes the first few ignitions, until the combustion within has heated the bulb, after which the blow lamp is extinguished. Starting tests described in a Danish Government report on a two cylinder Volund engine showed that nine to ten minutes was sufficient for starting the engine, measuring time from the instant of lighting the blow lamp on a perfectly cold engine.

The marine type is made, in large sizes, with a direct reversing system, which is accomplished by an early injection of fuel, which gives an explosion in the reverse direction, after which the timing of all events is automatically made correct for the reverse direction. The small size engines are provided with either reversing propeller or with reversing gear. These systems of reversing refer to quick maneuvering, as all of these engines can be started in either direction from stationary condition by compressed air. Danish Government tests on the reversal of the engines resulted in ten changes from ahead to astern and ahead within a period of sixty-five seconds, or an average of six and a half seconds per reversal.

Fuel Consumption

The range of fuels applicable to the Volund engine is quite wide, from any of the light oils to Diesel oil and many grades heavier. As to fuel consumption, this engine stands very well in comparison with others of this simple, rugged type. The guarantees of the builders are conservative and are considerably excelled in operation. The test by the Danish Government of the 80 horsepower two cylinder engine, already referred to, shows a fuel consumption of 0.505 pound per horsepower hour at full load and 250 revolutions per minute on crude oil of a specific gravity of 0.86.

In the lighthouse service of the Danish Government these engines have been used, to the exclusion of all others, for lightships, lighthouse tenders and cutters, and as stationary power for lights and fog horns. This speaks strongly for the feature of reliability. They have been applied to tugs, both harbor and ocean, fishing boats, trawlers, work boats, auxiliary schooners, power barges, pleasure craft, and to cargo and passenger boats for coastwise, channel and Baltic Sea service, as well as to auxiliary generator and compressor sets for large vessels.

Standardized Diesel Engines—IV*

Description of Engine With Automatic Valve Port Scavenging Arrangement—Simplified Valve Gear

BY H. R. SETZ

A PORT scavenging engine in the design of which the best accumulated observations have been utilized is outlined herewith. Identically the same frame structure is here used as previously described, and the only parts that differ are the cylinders, the lower cylinder rings and the cylinder heads (see Figs. 16, 17 and 18).

The cylinder barrel is cast integral with what corresponds to the upper centering flange or cylinder ring of the four cycle engine, thereby obviating the necessity of a rather unfavorable cylinder support at its upper end owing to the large bore which a separate cylinder ring would require to let the enlarged lower end of the cylinder through. The need for this enlarged lower cylinder end arises from the fact that a certain radial depth of material is required to accommodate exhaust and scavenging ports of suitable form, as well as water passages between these ports. The lower cylinder end is again slid into a centering ring which here takes the form of a water cooled exhaust belt over approximately one-half its circumference, while the other half contains scavenging air passages.

The same scraper rings and cored drain space for collecting combustion refuse as were previously described form the bottom end of the cylinder. All the advantages of freedom for lateral adjustment for each individual cylinder and elimination of boring in the cylinder beam are retained.

Like the valve-in-head two cycle engine, the exhaust from each cylinder is carried from the exhaust belt by means of a water cooled outlet through the side of the cylinder beam to a common exhaust header. The weight of the exhaust outlet and possible vibrations in the whole discharge line are taken off the joint at the cylinder belt by the provision of a flange slidably fitted over the exhaust outlet and fastened against the cylinder beam after all exhaust line connections have been made. Incidentally, this also facilitates forming an airtight joint where this exhaust outlet passes through the cylinder beam. The open underside of the latter is closed off by light steel plates, the outer edges of which are fastened against longitudinal and transverse flanges on the beam, while their inner edges are secured against the lower end of the cylinders. In a most natural manner the interior of the cylinder beam thus becomes a receiver space of very liberal proportions by means of which scavenging air can be conducted to each cylinder with a minimum of flow resistance. The complete surrounding by this scavenging air space of the cylinder belt containing the various ports lends itself to a splendid adaptation of the port scavenging principle.

Control Element

Reference to the transverse horizontal section in Fig. 18 shows the circumferentially disposed scavenging ports in the cylinder and their co-relation with radial passages through the cylinder belt. Each of these passages is provided with a control element the function of which is to check communication between the scavenging air receiver space and the interior of the engine cylinder during that short interval after the piston first uncovers the scavenging ports until pressure release has taken place through the exhaust ports. Enlarged views

* Copyright, 1921, by H. R. Setz.

of such a control element are given in Fig. 19. It comprises four flat, narrow strips *A* of ordinary spring steel, lightly held against the flat face of cage *B* by springs *C* in the retainer *D*. These steel strips or check valves open inwardly, their lift being limited by retainer *D*. They permit flow only into the cylinder, as soon as the pressure in the latter drops below that of the scavenging air in the surrounding receiver space, and return to their seats at the least tendency of the flow to reverse.

From this it will be observed that the action of these valves is entirely automatic. Owing to the narrowness of the passages in cage *B* which they control, with the resulting shortness of unsupported span, the load conditions to which these check valves are exposed can easily be met with very thin steel strips, which as a consequence become extremely light in weight; their response to the slightest pressure difference is practically instantaneous. Positiveness of their action is furthermore assured by the very small lift required to uncover the full passage area through cage *B*.

In their construction these valves are practically identical with what in modern air compressor practice are known as "feather valves," which also consist of long, flat steel strips controlling air passages in the form of narrow slots. Similarly their action closely corresponds to that of the "feather valves" except that the latter are usually exposed to higher pressures and also less favorable temperature conditions than in the present application. This applies particularly to air compressor discharge valves which not only have to stand practically continuously the full delivery pressure, but also are exposed to the high temperature as the compressed air flowing past them when being discharged from the cylinder. When used as check valves on scavenging ports a stream of cool air only flows past these valves. Even during the short interval preceding pressure release through the exhaust ports their location at the end of what is at that moment a deep, dead pocket, together with the protection afforded by retainer *D*, prevents them from coming into direct contact with the hot gases of combustion.

Control Arrangement Simple to Manufacture

Attention is called to the admirable simplicity of this scavenging port control arrangement from the manufacturing point of view. The facility for delivering scavenging air to any point around the circumference of the cylinder by virtue of the latter being surrounded by the liberal receiver space makes it possible to give the scavenging ports the form of short radial passages through the side walls of the cylinder. These passages being all alike in section and radial length, and uniformly spaced circumferentially, the cylinder castings become greatly simplified and considerably easier to make than is the case on some recent two cycle engine cylinder constructions. No exceptional finishing processes are required, the only machining operation called for being that of milling the flat end faces on the outside of the cylinder wall. Likewise the parts of the scavenging valves, i. e., cages *B* and retainers *D*, require only plain milling. It should be noted that these parts are of a form which permits their being machined by the process known in modern

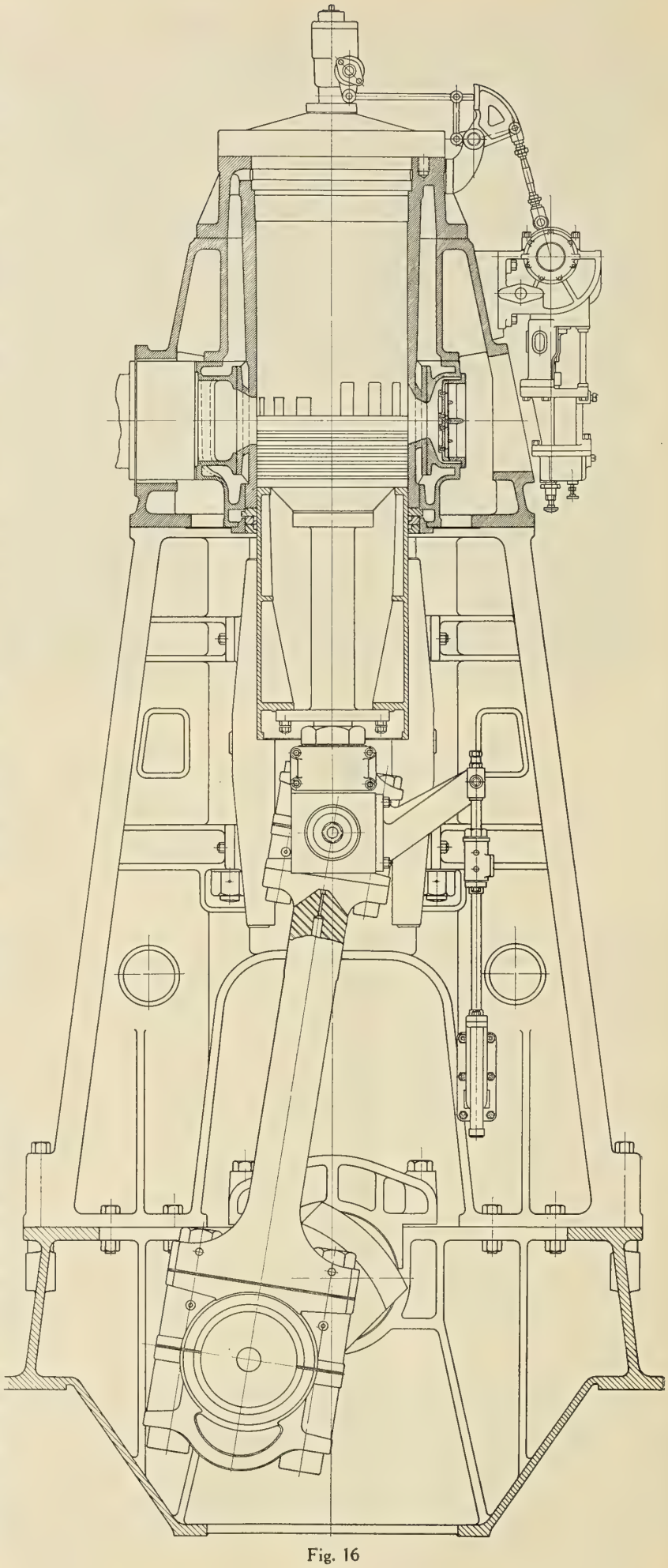

Fig. 16

STANDARDIZED DIESEL ENGINES

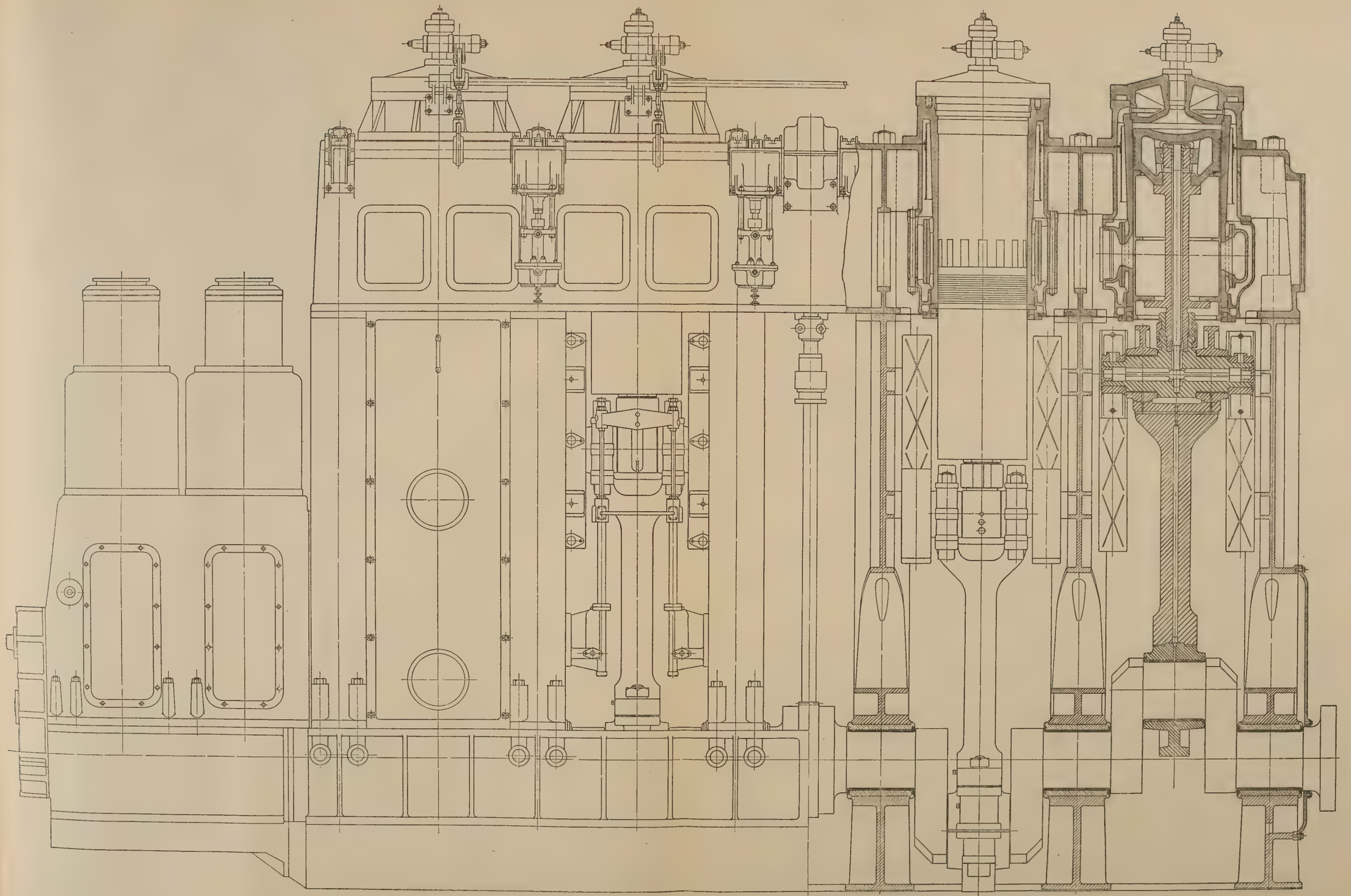

Fig. 17

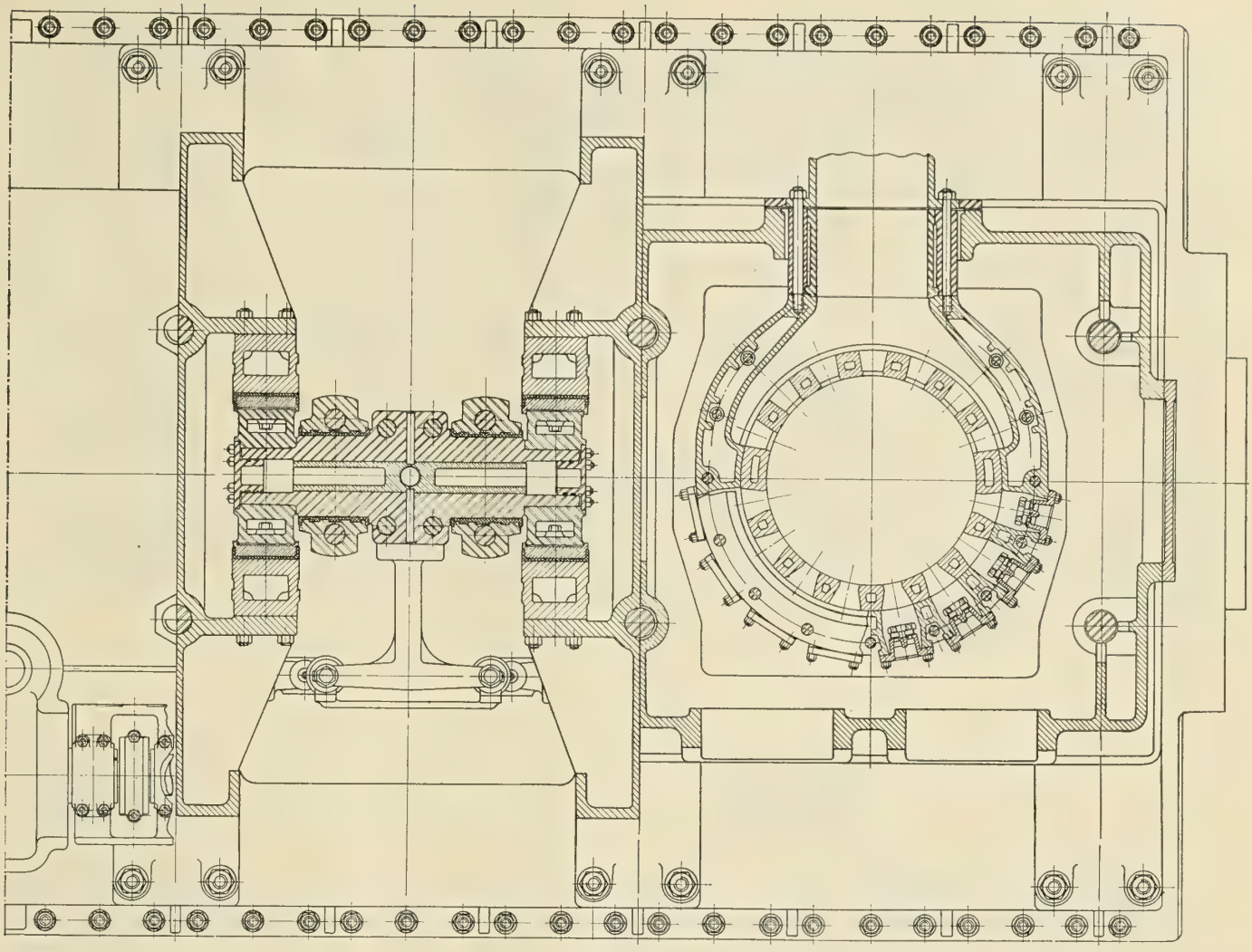

Fig. 18

manufacture as continuous milling. This, together with the fact that the material used is cast iron, reduces the cost for these parts to an almost negligible quantity, especially since they are not subject to any wear whatsoever. The only parts that could possibly require occasional replacement are the valves themselves, which, as compressor experiences show, is an insignificant item.

These valves are easily accessible through large openings in the side of the cylinder beam, only light sheet metal covers being used to close off the latter. Owing to the provision of individual control valves in front of each port, any one of the latter can be closed off entirely if desired without affecting delivery of a full stream of scavenging air through the other ports.

Comparative Study of Port Scavenging Systems

Lest it be thought that the constructive and mechanical advantages just described have been the only incentive for their adoption, a study of the diagrams in Fig. 20 is invited. The sketches at the left indicate the particular system of port scavenging that is to be discussed and the curves on the right show the inlet and exhaust areas made available in each. In all the diagrams abscissae represent piston travel and ordinates are proportional to areas. The curved lines beginning near the upper left hand corner of the diagrams is the end or "toe" of a two cycle indicator card and is the only line which measures pressures. In all cases the double cross-hatched areas represent exhaust port openings and the spaces filled in with vertical line shading show the net maximum areas available for the passage of scavenging air. Although the curves are approximate, they have been drawn as nearly as possible to the same scale and form a convenient basis for the comparative study of the various types of port scavenging which they portray.

Diagram *A*

At *A* is shown the most elementary type of port scavenging, in which inlet ports lower than the exhaust ports are used. The short scavenging period and small scavenging port area make it necessary to resort to high scavenging air pressures, in order to attain anything like the requisite velocities. High air velocities are objectionable on account of too turbulent scavenging, and because they make necessary a large excess volume of air to make up for the resulting appreciable loss through the exhaust ports. All this calls for a large scavenging pump and excessive negative work. A further loss of air results from the early closing of the scavenging ports, permitting the air pressure in the cylinder to drop until the piston covers the exhaust ports, when compression begins with the low initial pressure P_1. These phenomena account for the fact that engines of this type have an output 20 to 25 percent lower than more modern types of two-cycle engines and also are less efficient.

Diagram *B*

A much more favorable method of port scavenging is that where a row of valve controlled scavenging ports is superposed over the single row just described, placing the top edge of this second row higher than that of the exhaust ports. Diagram *B* permits of a detailed tracing out of the various phases of this scavenging cycle. Uncovering the upper row

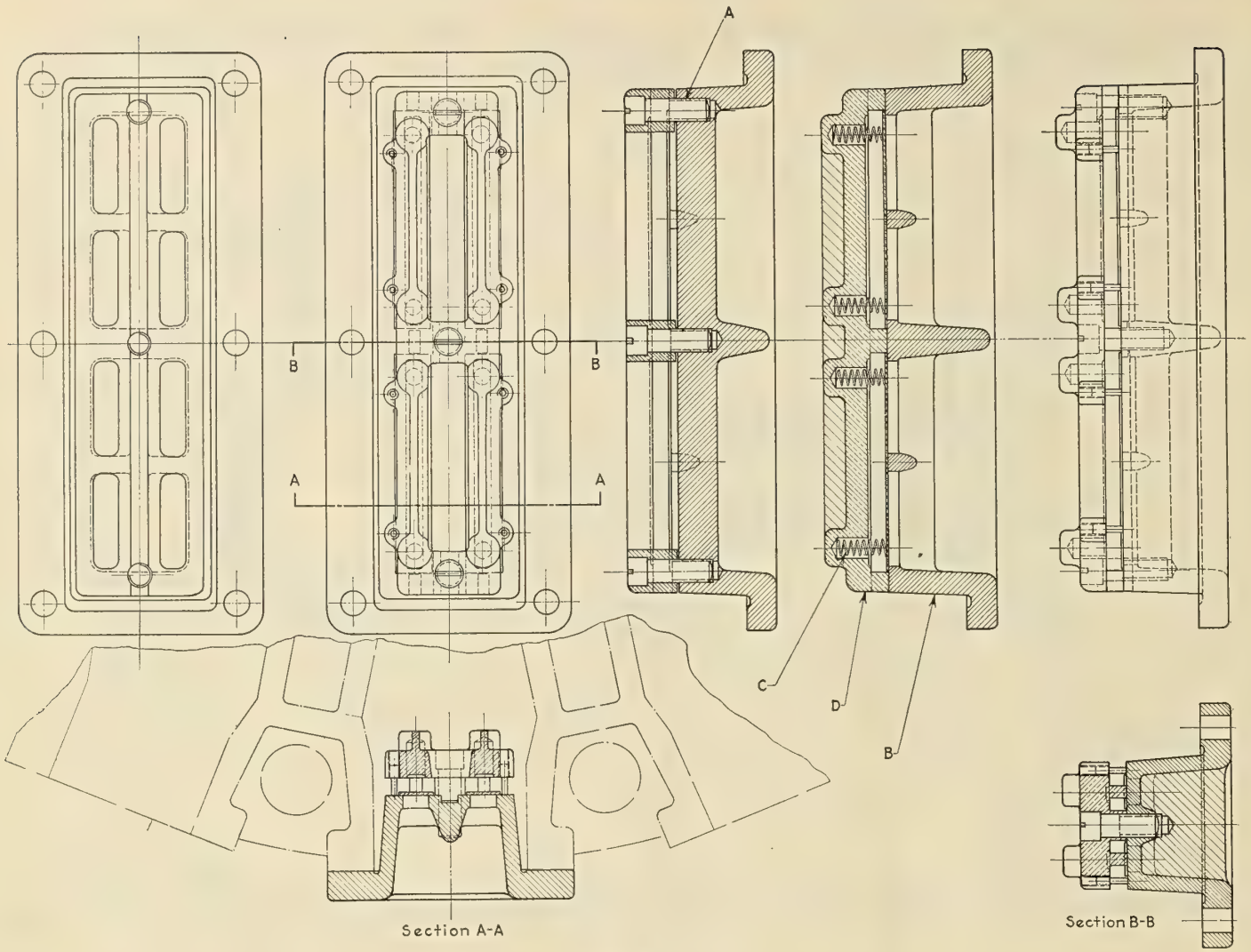

Fig. 19

of ports has no effect at first because at that time they are still obstructed by the rotary valve which controls their opening; until pressure release through the exhaust ports has taken place, the wearing surfaces of this valve are therefore subjected to the momentary cylinder pressure.

The next event is the creeping commencement of opening of the rotary valve, which begins to yield a substantial total opening only when the area of the bottom ports shows its effect. Owing to the danger of a blow-back into the scavenging receiver, the opening of the rotary valve must be retarded to a point which will give a margin of safety at any load and an availability of area corresponding to this margin must be sacrificed.

After the re-covering of the lower scavenging ports air continues to enter the cylinder through the upper ports until these also are re-covered by the piston, i. e. beyond the point of re-covering the exhaust ports, this being known as the period of super-charging. The area of the rotary valve opening is maintained at a substantial excess over that of the auxiliary (upper) ports until well after the super-charging period has ended.

The irregularity of the total net area in the neighborhood of the dead center is due to its summation of the straight port opening line and the curve of valve areas. Attention is called to the super-charging pressure P_1, which is notably higher than that shown in diagram *A*, in spite of the fact that a considerably lower scavenging air pressure can be used because the total port area is so much larger. It is to be noted, however, that the center of gravity of the area covered with vertical line shading is considerably to the right of the dead center, the interpretation of which is that a substantial part of the scavenging area is made available at a period when the piston is accelerating and when the time for utilizing the area is becoming short.

Diagram *C*

Diagram *C*, in view of what has been said, is largely self-explanatory. Attention is called to the abruptness of the valve lift curve and to the location of the center of gravity of the vertical line shading closer to the dead center than was the case with diagram *B*.

A serious disadvantage of this particular method of port scavenging is the size of the single valve required to control the entire port area and scavenging air supply. The valve lift becomes of necessity quite high and the cam must be made very steep in order to obtain as large a valve lift area as is desirable near the dead center. Considering the very appreciable weight of such a valve, the resulting kinematic forces become excessive and even where two valves are used, as has been done, these forces have proved to be too great for continuous satisfactory operation.

Diagram *C* is applicable also to valve-in-head two-cycle engines (Fig. 15) with the single modification that the dotted portion of the valve life curve would become full and the vertical line shaded area representing total scavenging opening would increase.

Diagram *D*

Diagram *D* shows scavenging area development in an engine having port scavenging controlled by automatic plate valves. Almost instantaneous development of the maximum

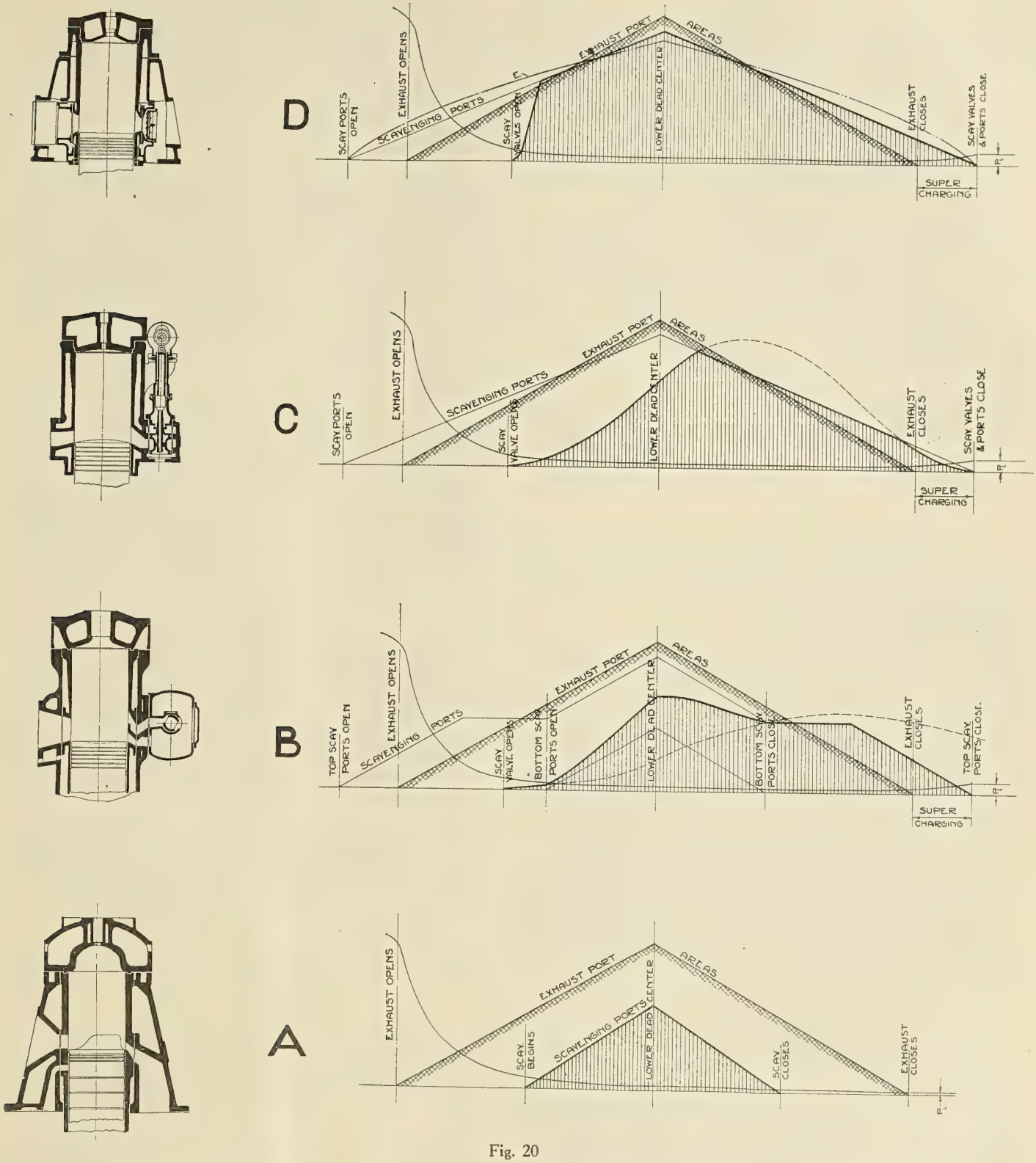

Fig. 20

possible scavenging area, its long duration over a period of slowest motion on the part of the piston and effective supercharging stand out so prominently that comment is unnecessary.

The considerably larger useful scavenging area obtainable here than with the same size ports under either of the methods illustrated at *C* or *B* make it possible to resort to lower scavenging air velocities. The necessary air pressure, and therefore the negative work, become less and the exhaust gases can be expelled at a minimum expenditure of energy. The dot-and-dash curve shows the area development that can be produced by suitably shaping the contour of the scavenging ports so as to further a still more effective supercharge.

The absence of partitions in the scavenging ports, such as are typical of the construction shown at *B*, not only adds greatly to the simplicity of the casting and manufacture but also provides the means for inducing proper radial and axial flow of the scavenging air as it enters the cylinder.

Referring to Fig. 21, *H* shows the position of the piston at the moment pressure release has taken place through the exhaust ports. Thanks to the immediate opening of the automatic valves, scavenging air rushes in full radial streams through the unobstructed ports towards the interior of the

cylinder until the momentary position of the piston causes a sudden and energetic deflection upwards, along the steeply inclined upper edge of each port. The resulting general direction of each stream is indicated by the heavy arrow; they all converge towards the cylinder center and top. As these individual streams impinge upon one another, principally within that half of the cylinder containing the scavenging ports, a further deflection towards the cylinder top occurs, which effectively displaces the exhaust gases there

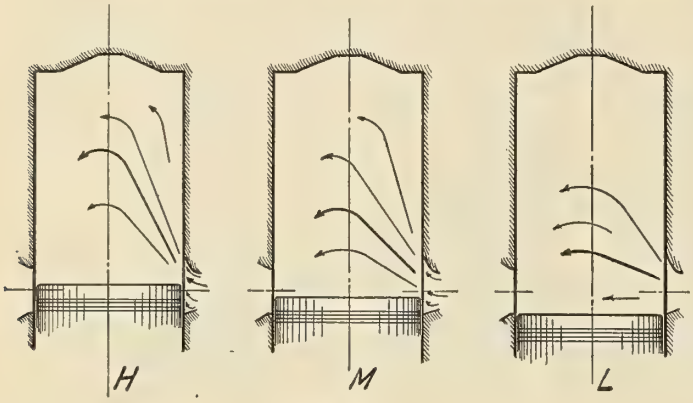

Fig. 21

and initiates their expulsion in the general direction along the opposite cylinder wall. How this process of expulsion is continued as the piston approaches the dead center position is clearly shown at *M* and *L*.

The superiority of this method of scavenging with full streams of air can now be appreciated compared to that shown at *B* where, owing to the creeping opening of the rotary valve, the streams entering the upper ports will over a large portion of the scavenging period only partly fill these ports and are therefore not very energetically deflected by the thin baffles which in these ports are necessary to take the place of the piston as a deflector. The fact that during all this time another series of air streams enters the cylinder in a different direction from the upper ones does not add to the effectiveness of scavenging. While the latter objection does not hold true with method shown at *C*, here, also, owing to the much smaller passage area uncovered by the valve than by the piston until far past the dead center, the streams of air entering the cylinder over the largest portion of the scavenging period fail to perform their function with that precision and positiveness that is so pronounced with method *D*.

Point at Which Scavenging Begins

A feature worthy of special consideration is the point at which scavenging will begin. Fig. 22 shows a light spring indicator diagram taken on a port scavenging engine of the type shown in Fig. 20-*A*. The capacity per cylinder of this particular engine is 100 brake horsepower at 225 revolutions, with a piston speed of 750 feet per minute. The full lines apply to a diagram obtained with the engine running practically at full load whereas the dashed lines apply to about 1/3 normal load.

The outstanding feature in this diagram is the momentary pressure drop of the expansion line to 3½ pounds below the atmospheric line at full load and to 1½ pounds below the atmospheric line at 1/3 load. As is well understood to-day, this pressure drop is due to inertia of the gas column in the exhaust line; it is most intense at the heaviest load, owing to the higher pressure in the engine cylinder at the moment the exhaust ports are uncovered, resulting in greater velocity of the exhaust gases out through the ports. It will be observed that at the moment the scavenging ports are uncovered the pressure in the cylinder is at either load less than that of the scavenging air, which in this particular engine was not quite 2½ pounds per square inch when the diagrams were taken. Both the full load and one-third load pressure lines intersect the scavenging air pressure line at a point to the left of the point where the scavenging ports open; scavenging could therefore begin earlier, at full load almost 30 percent earlier, if the ports were higher.

This is exactly what automatic port control makes possible and it is at these intersection points of the respective pressure lines that these control valves open. We see from this that where the load is heaviest, and the introduction into the cylinder of the greatest weight of pure air most essential, the method of scavenging shown at *D* automatically adjusts itself to this condition; scavenging not only starts earlier at heavier loads but also is initiated with greater intensity, owing to the greater drop below atmospheric pressure in the engine cylinder. This is a further reason which makes possible a reduction of the scavenging air pressure.

Automatic Port Control Simplifies Valve Gear

Automatic port control thus satisfies all essential requirements to an extent far beyond accomplishment with mechanical port control. A most beneficial advantage resulting from the use of automatic port control valves is the simplicity of the engine valve gear; the only remaining mechanically operated valve is the one required for fuel injection, which is actuated by short push rods combined with means for valve lift variation.

Reversing can be accomplished by the well-known very simple expedient of a helical sleeve, which also permits of timing variation of fuel valve to suit load and speed.

The cam shaft drive consists of the usual vertical shaft with helical gears, the satisfactory operation of which is greatly enhanced by the absence of any appreciable or abrupt loads. Each fuel pump is driven by its own eccentric from the cam shaft, establishing for every cylinder the same and unchangeable time relation between delivery stroke of the pump and point where injection into the cylinder occurs. Speed and safety governors are mounted on the vertical shaft.

The absence of any valve pockets with side outlets makes it possible to insert the cylinder head over its entire depth, except for the top flange necessary for fastening, into the

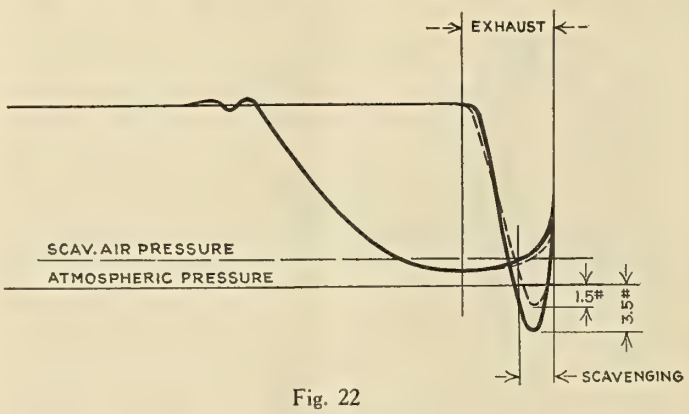

Fig. 22

cylinder bore. A comparatively light casting is the result. By this method the plain cylinder wall is continued well beyond the point where heat is imparted to it in the combustion chamber and the absence of any flanges or other material accumulations in this region of highest temperature permits of direct and intensive cooling, low mean temperatures and freedom from heat distress. The simplicity of the cylinder head, with only one small opening in the center for the fuel valve, and its favorable conical form also ensure immunity against heat influences.

(*To be concluded.*)

Balancing Engines—II

With Special Reference to Internal Combustion Engines

BY C. H. PEABODY, DR. ENG.

HAVING obtained from the discussion in the last issue a clear idea of the kind and magnitude of the accelerating forces that occur with reciprocating engines, we can take up the matter of balancing such engines. We will first consider internal combustion engines which have the greatest necessity for balancing and for which fortunately a complete balance can be the most readily made in practice.

Two Kinds of Balancing

An engine may be out of balance and may shake badly if (1) the crank shaft is not balanced and (2) if the reciprocating or accelerating forces are not balanced. These two systems of forces are entirely unlike and in any satisfactory balance they must be treated separately. A complete balance of the crank shaft is always possible; a satisfactory balance of the reciprocating parts can be had only for certain combinations. In some cases the ill effects of lack of balance of reciprocating parts may be mitigated by purposely introducing unbalanced rotating masses, and in such case the remedy brings in its own difficulties.

Balancing Locomotives

The popular idea of balancing engines is biased from the practice in America of putting counterbalance weights on the driver wheels of locomotives. Locomotives have fairly long connecting rods, six or six and a half times the crank being often used; this in part avoids extreme inequality of accelerating forces. But the pistons, crossheads, connecting rods and side bars form a heavy combination running at high speed so that large accelerating forces are developed which are applied at the outside of the frame of the engine. These forces come alternately on one side and the other of the locomotive and jerk the pilot violently from side to side, which is very unpleasant and may be dangerous. The counterbalance weights partly compensate this action and reduce the jerking; they at the same time bring in an up-and-down force that is bad for the rails and their fastenings. There is no parallel between this condition and the action of vertical engines as used on automobiles and various boats and ships.

Balancing Crank Shafts

Before taking up the process of balancing a crank shaft, let us consider the nature of the forces that occur when an unbalanced mass rotates at high speed. If the rotation is uniform, the centrifugal force developed is constant; it passes through the axis of rotation and the center of gravity of the rotating mass and moves around with it, pointing in all directions successively as it goes around the circle.

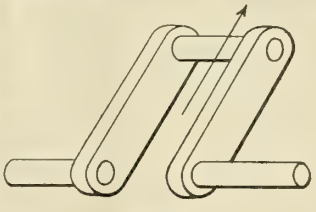

Fig. 3

The case is fairly simple for a single symmetrical crank like that represented by Fig. 3; the centrifugal force can be represented as applied at the center of gravity something less than half the length of the crank from the axis; as it goes around it pulls up against the caps of the main bearings and, if there is any looseness or elasticity in the bearings, the force will develop it. The remedy is to extend the crank webs, either the original forgings or by fastening on counterweights until the center of gravity is pulled into the axis. Whenever this can be done it is the best practice; a certain automobile was advertised as a supersix because the crank shaft being so balanced it could run fast. Even though a crank shaft, as for a six cylinder gasoline engine, has complete natural balance such counterweighting is desirable because it relieves the crank of the centrifugal force which will develop unnecessary friction if nothing worse. When such a six cylinder engine has only a few intermediate bearings and the crank shaft is slender, it may be bent enough to wear out the bearings even though made of special steel and so strong that there is no risk of breaking.

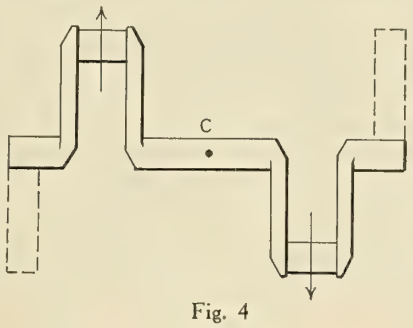

Fig. 4

In dealing with crank shafts and other rotating bodies, it is customary to speak of standing balance and running balance. This distinction can be brought out by considering the double opposed cranks of Fig. 4; if symmetrical and well made, the cranks will be in standing balance, or can readily be made so; that is, they will remain in any position when placed on horizontal knife edges. But if run at speed in bearings two centrifugal forces will be developed, equal and opposite but applied at some distance apart. They do not tend to move the shaft bodily as does the single centrifugal force of Fig. 3 but they rock the ends back and forth in the bearings and may cause a very troublesome shaking.

There are two methods of balancing the rocking couple of Fig. 4; one is to balance the cranks individually and the other is to put on outside balance weights as indicated by the dotted lines. This latter method will require less mass in the counterweights because being further apart and the centrifugal couple due to them having a longer arm the forces may be less; for example, if the distance between the counterweights is half that between the cranks then they may be half as large. But this outside balancing produces a new couple to bend the shaft. The method of outside balance may sometimes be used to advantage with two or three cranks provided the shaft is stiff enough.

There is one matter which is commonly neglected in the discussion of balancing the crank shaft, and that is the action of the connecting rod. The motion of the connecting rod is peculiar, one end moving uniformly in a circle and the other moving on a straight line; a proper mathematical discussion as given by Professor Lanza is very complicated. When the rod is short and the body slender, while the ends are heavy a fairly good result will be obtained if the two ends are weighed, supposing the off end on a knife edge; and the weights so found are assumed to be applied one at the crank pin and the other at the wrist pin; this was done in the calculation for the Jordan engine, the wrist pin end being added to the weight of the piston. In determining the counterweight for the crank the weight of the crank pin end of the connecting rod should be added to the weight of the crank pin itself; the crank will consequently appear to be over counterweighted and may not show a standing balance

on the knife edges. If it is desired to make a test on the knife edges then three weights may be prepared each equal in weight to the crank pin ends of a connecting rod, and these may be clamped to the crank pins during the test. If the connecting rods are well made and are brought to the same weight, this method will give good results.

Single Cylinder Engine

There is little that can be done by way of balancing a single cylinder engine, and if it runs fast it is likely to give trouble. The crank shaft of course may be balanced, including the crank end of the connecting rod. Small engines often have an overhung crank and then the counterweight, if applied, is to one side and a rocking couple will be developed as discussed in Fig. 4.

If such an engine shakes very badly, it may be counterweighted like a locomotive. The best result will be found by experiment; the maximum counterweight applied opposite the crank pin and at the same distance from the axis of the shaft may be equal to the combined weight of the piston, rod, crosshead and wrist pin end of the connecting rod; when there is no piston rod and crosshead the corresponding weights do not appear. If it is not convenient to apply the counterweight at the distance of the crank pin, a like result may be had by a weight placed at a convenient distance, provided that the product of the actual weight by the distince of the center of gravity from the axis of the shaft is equal to the weight first found by the length of the crank. Single crank engines often have a flywheel and the counterweight, if used, is put on that wheel. The piston and the counterweight, being out of line, develop a couple which sets up a rocking that may be annoying.

To understand the action of a counterbalanced engine consider the acceleration by aid of Table II (see May issue); the acceleration is greatest at the beginning of the down stroke, decreases rapidly to zero at about 80 degrees or 0.4 of the stroke, and then increases more slowly to the end of the stroke.

The centrifugal force acting at the center of gravity of a revolving body can be computed by the expression:

$$\frac{4\pi^2}{3{,}600} n^2 r \frac{W}{32.2},$$

where W is the weight of the revolving body, 32.2 is the acceleration due to gravity, r is the distance of the center of gravity from the axis and n is the number of revolutions per minute. Comparing this with harmonic motion; that is, the motion of a slotted crosshead, the expression will be recognized as that used for computing the accelerating force at the beginning of the stroke. This will appear natural when we consider that at the end of the stroke the slotted crosshead is brought to rest by the crank pin and that the retardation (negative acceleration) is the force the pin exerts to prevent the crosshead from flying off into space along the straight line of its motion. A body having the weight of the crosshead and piston, hung on the crank pin and revolving with it, will pull with that same force all around the circle. A counterweight for the piston and attached parts can be adjusted to produce a centrifugal force equal to the mean value of the accelerating force for the piston and attached parts at the ends of the stroke. From Table II (see May issue), it will be seen that the mean value is proportional to

$$(0.01371 + 0.00822) \div 2 = 0.0110,$$

which is the factor for harmonic motion. At the top end of the stroke this will be insufficient to start the piston; with a connecting rod four times the length of the crank, the insufficiency will be

$$(0.01371 - 0.0110) \div 0.0110 = 0.25$$

of the acceleration required to start the piston and connected parts; at the bottom of the stroke the centrifugal force will be a like amount in excess.

Without going further into detail we may say that the rotating mass will supply the equivalent of a harmonic acceleration and retardation, which will mitigate the effect of the piston and connected parts, but will not properly balance that effect. At the same time there will be introduced a transverse component from the centrifugal force which will have the same effect as a transverse slotted crosshead, and which may bring about a very annoying shaking. It will depend on the structure of the frame carrying the engine, whether it can best endure vertical or transverse shaking. A ship is likely to be stiffer vertically and may shake worse after the engine is counterbalanced; an open boat, on the contrary, may be benefited.

The single cylinder steam engine has had a wide use especially for small powers; it commonly has a flywheel, but for many purposes it runs well enough without. Small internal combustion engines frequently have one cylinder; they always have a flywheel as there is but one working stroke for each revolution when working on the two stroke cycle, and one for two revolutions on the four stroke cycle. The heavy flywheel reduces shaking as well as providing for steady running.

Free Force and Rocking Couple

Almost all discussions of balancing introduce the terms "free force" and "rocking couple." The accelerating force for a piston is called a free force, and two opposite forces like those of Fig. 4 are called a rocking couple. These terms are commonly ill defined and used obscurely; they may serve to bring out the fundamental facts of mechanics, i. e., that a force can be balanced only by an equal and opposite force acting along the same line, and further that a moment can be balanced by an equal and opposite moment.

To bring out this feature we will consider a simple case of vibration, because the shaking by an unbalanced engine is a combination of a fluctuating force with a vibrating body. Suppose that a plank is laid across two horses which are about a quarter of the length from each end. The plank will have a natural time of vibration, which a man may develop by standing in the middle and jumping up and down. By trial a man may time his motion to the natural time of vibration and by slight effort may set up violent vibrations. In like manner a single cylinder engine near the middle of the plank and run at synchronous speed will produce violent shaking.

A ship has also a natural time of oscillation with quiescent points called nodes at about one-third of the length from the ends. A single cylinder engine at or near the middle of the length will produce violent shaking, if its period synchronizes with that of the ship. This matter is not simple and, fortunately, we need not go far in it because we are more interested in balancing engines, and if the balance is fairly satisfactory we need not trouble about the oscillation of the ship.

Returning to our plank on its horses, we may consider that a man may set up an oscillation by standing astride one of the horses and throwing his weight first on one side and then on the other; a two cylinder engine, with opposite cranks, run at synchronizing speed will do the same thing to a ship if placed at or near a node. If only the case were as simple as the preliminary statement, we could announce the policy, keep free forces from the middle of the ship and rocking couples away from the nodes; but engines must go where they can and a ship will develop amazing oscillations, due either to free forces or rocking couple.

Two Cylinder Engines

Two cylinder engines are usually of types, (1) with cranks opposite like Fig. 4, or (2) with cranks at right angles.

The first type, with opposite cranks, is commonly used for internal combustion engines, and the second type for steam engines. The first type has a partial balance of the accelerating forces of the pistons; with a connecting rod four times the crank, the piston at the top beginning the down stroke has 1.7 times the acceleration of the other, leaving the 0.7 to set up a free force. As compared with a single cylinder engine of the same power, this two crank engine has a considerable advantage, even though the two accelerating forces, one up and one down, may set up a rocking of the engine. Such engines being usually small and cheap are likely to be unbalanced.

The two crank steam engine is habitually used for all types of reversing engines, on locomotives, hoisting engines and to a considerable extent on small steamers. Even without a flywheel it gives a fairly even rotation. The balancing of locomotives has already been mentioned; other engines of the type are commonly unbalanced. Two cylinder marine engines with direct connection to the propeller do not usually run very fast and the shaking that takes place is taken as inevitable, especially as it cannot well be remedied. Counterweights on the crank shaft are unpopular as they interfere with ready access to the shaft bearings. This so-called quarter-crank engine has both free forces and rocking couples.

A very good balance has been obtained for two cylinder steam engines for driving blowers. The middle bearing of the shaft was suppressed and the cranks were brought near together, so that the inner crank webs coalesced. The engine, which was usually horizontal, had one cylinder on one side

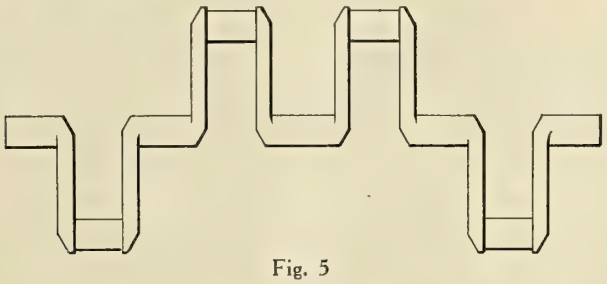

Fig. 5

of the crank shaft and the other cylinder on the opposite side. The two pistons consequently started at the same time to move toward the shaft and both had then their maximum accelerating force; the pistons had the same weight and the accelerating forces were completely balanced. Since the cranks were close together, the rocking couples were small and gave little trouble. In the early history of automobiles this type of engine with cylinders on opposite sides of the crank found some favor; it will be remembered that some automobiles had but one cylinder, even as some motor cycles have to this day.

Three Cylinder Engines

The three cylinder engine with three cranks evenly spaced around the circle requires careful consideration both from its deservedly high reputation with steam engineers and because a discussion of this type leads to an arrangement with six cylinders which gives a complete balance, an arrangement most commonly used for automobiles.

Except for very large powers the three cylinder triple steam marine engine has been found very satisfactory, so much so that it is the commonly accepted type. A fairly satisfactory expansion of the steam and a good distribution of power can be had and the engine has a high reputation for steadiness and smooth running. Usually the pistons have varying weights, depending on their diameters, and in such case the free forces are not in balance; there are also decided rocking moments.

If the cranks are evenly spaced and if the three pistons are made to have the same weight, there will be no free force. To demonstrate this important point we may turn to Table II (see May issue), and select the proper acceleration factor at intervals of 120 degrees; thus for the ratio of 4 for the connecting rod and crank we have:

Angles	Accelerating Factor	Accelerating Force
0	0.01371	$0.01371 \frac{W}{g} n^2 r$
120	0.00685	$-0.00685 \frac{W}{g} n^2 r$
240	0.00685	$-0.00685 \frac{W}{g} n^2 r$
		Sum zero

The force at 120 degrees is a retardation and therefore is negative and at 240 degrees the acceleration acts upwards and is also negative. At any other angle the same result is found; thus at 40 degrees we have:

Angles	Accelerating Factor	Accelerating Force
40	0.00893	$0.01091 \frac{W}{g} n^2 r$
160	0.00818	$-0.00818 \frac{W}{g} n^2 r$
280	0.00075	$-0.00075 \frac{W}{g} n^2 r$
		Sum zero

A stray unit in the last decimal place is, of course, due to the unavoidable inaccuracy of that place of figures.

Using this property of the three crank engines one of the best American builders of torpedo boats has found good results by simply giving the same weight to all the pistons. The rocking moments are taken care of by tying the tops of the cylinders fore and aft to the framing of the ship.

Four Cylinder Engines

The accepted arrangement of cranks for the less expensive automobiles is given by Fig. 5, which will be recognized as the two crank arrangement of Fig. 4 doubled and reversed. The two pistons attached to the middle cranks of Fig. 5 are at the tops of their strokes and their accelerating forces are 1.7 times those of the pistons attached to the outer cranks, if the connecting rod is four times as long as the crank. The accelerating forces are unbalanced to the same extent as for the two-crank arrangement of Fig. 4; but there is no rocking moment provided that the crank shaft is symmetrical fore and aft. The automobile engine habitually runs on the four stroke cycle and consequently this arrangement provides an explosion for each half revolution; the four crank engine of this type requires a flywheel like the single cylinder steam engine and it gives nearly as good a rotative effect. Since this engine, like all automobile engines, is unclutched and started without a load, the four crank arrangement with a flywheel works fairly well in all kinds of service.

Gasoline engines used for propulsion of small boats, yachts, etc., run on the four stroke cycle. They may have a single cylinder, two cylinders or four cylinders; some high power boats have a large number of cylinders. The two and four cylinder types have the cranks like Fig. 4 or Fig. 5. Heavy oil engines, whether Diesel engines or hot bulb engines, may work on the four stroke cycle or on the two stroke cycle with scavenging arrangements. In either case a two cylinder engine will have opposite cranks like Fig. 3; the two stroke cycle with two cranks is nearly equivalent to a single cylinder steam engine in steadiness of running.

The heavy oil engine with four cylinders working on the

four stroke cycle will have opposite cranks like Fig. 5; it is free from rocking moments and not very badly out of balance. Should such an engine work on the two stroke cycle, the cranks may be set quartering; the best arrangement is to have the first and second cranks opposite; the second and third cranks are also opposite, but quartering from the first pair of cranks. This arrangement gives nearly as steady running as a quarter crank two cylinder steam engine. The engine has both free force and rocking moments, there being no satisfactory way of balancing the pistons. The lack of balance may not be very troublesome, especially on low powered ships like freighters.

A great deal of ingenuity has been spent on attempts to balance four crank steam engines; some think that there has been a waste of ingenuity. In the first place, it may be premised that the reasons for going to four cranks are (1) to provide for quadruple expansion or (2) to divide the low pressure cylinder when it becomes of inconvenient size. Quadruple engines were introduced more than thirty-five years ago, but have not found general acceptance, the gain in economy being in part offset by the complication and the difficulties introduced by high pressure and temperature. The cranks are usually spaced uniformly around the circle because it is convenient to have the cylinders arranged in order of their size and pressure, and because it is very convenient to be able to maneuver the engine with steam bypassed to the second intermediate and the low pressure cylinder. Another arrangement is to have the low pressure and second intermediate cranks opposite, and the other two cranks opposite, but at a quarter circle from the first pair. In any case the pistons commonly are of unequal weight and the engine has unbalanced free forces and rocking couples; the lack of balance is not very troublesome.

When a triple engine has two low pressure cylinders they each develop one-sixth of the power of the engine; the high and intermediate cylinders each develop one-third of the power. This unequal distribution of power makes the engine inferior, in this respect, to the regular three crank triple marine engine. The natural arrangement of cylinders is to place the high pressure cylinder forward and the two low pressure cylinders aft. In such case the two low pressure cranks may be opposite and the two other cranks are also opposite, but quartering from the first pair; the engine may be maneuvered by the intermediate and low pressure cranks.

Sometimes a triple four cylinder engine has the low pressure cylinders placed at the ends of the engine, one forward and the other aft; the intermediate and high pressure cylinders are placed in the middle. The steam lead is fairly simple, being from the high cylinder to the intermediate and the aft low pressure cylinder in regular order; the lead from the intermediate past the high pressure cylinder to the forward low pressure cylinder is rather long. The engine can be maneuvered from the intermediate and low pressure cylinders. The cranks may be set in the following order, forward low pressure crank at 0 degrees, after low pressure crank at 90 degrees, high pressure crank at about 150 degrees, and intermediate crank at about 250 degrees. The two forward cranks are 30 degrees from being opposite and the two after cranks are 20 degrees off. The low pressure piston rods, crossheads and connecting rods are lighter than those for the other two cylinders; the pistons are somewhat larger and heavier than the intermediate piston; though not commonly done, the weights of all reciprocating parts may be made the same for all cylinders.

By a somewhat complicated system of graphical construction an investigation can be made to develop the free forces and rocking moments all round the circle, taking account also of the valves which are heavy and have an appreciable effect. After a thorough study has been made efforts may be set on foot for improvements by changing weights of the pistons and the crank angles. With care and skill good results may be had by experts. A special method of balancing is patented under the name of the Yarrow-Schlick-Tweedy system, which follows this same line, but the details are unrevealed. There is much difference of opinion concerning the value of the method here sketched out, and of the patented method named. In some cases satisfactory results are had and in others not. Probably the success or failure may be due to the relative conditions of hull and engine. Theoretically a complete balance of a four cylinder engine is impossible.

The Six Cylinder Engine

It has been shown that a three cylinder engine with cranks spaced equally and with all pistons having the same weight, has complete balance of free forces; there remain rocking couples. Now if we take two such three crank engines and place them in line with the two cranks together at the middle of the combination we will have an arrangement that is free from free forces and rocking moments; or perhaps we should say, that, if the base of the engine is stiff enough, all the dynamic effects will be self contained.

This six cylinder arrangement is standard for all high class automobiles and in practice leaves little to be desired. The rotative effect is not so good as for a quarter crank steam engine, but the engine has a flywheel and is started unclutched, so that there is small reason for complaint.

The desirable type of engine for marine propulsion whether with Diesel engines or hot bulb engines is this six crank type, both for two stroke cycles or four stroke cycles.

Multiple Cylinder Engines

In the attempt to get more power or greater smoothness of action both for automobiles or for aeroplanes, various combinations having more than six cylinders have been used. Usually such engines have a *V*-frame, with the cylinders set at an agle so that two connecting rods may act on one crank. There are two favored types, one having eight cylinders and the other twelve; that is, we may have twin fours or twin sixes. The twin six is completely balanced because each element is so individually. The twin four is not completely balanced; the engine runs very smoothly and has the credit of taking hard and irregular roads better; it is shorter than a six cylinder engine of the same power. Except for the multiplicity of cylinders and appurtenances the twin six appears to be ideal for automobiles.

But a summation of all conditions leads to the conclusion that for internal combustion engines the six crank engine is the most desirable for land and sea.

Allowing for Contraction While Making Large Rudder Frame Welds

THE problem of allowing for cooling contraction after pouring thermit welds was handled in an interesting manner during the recent repair of the eleven-ton rudder frame of the steamship *New Rochelle* of the United States Mail Steamship Company, which was cracked in three separate places, the fractures extending from about 4 inches to 6 inches into the frame.

Before making these repairs the rivets which fastened the rudder plate to the rudder frame were first removed in order to prevent the plate from buckling due to contraction when the weld had cooled. The fractures extended only part way through the chunky sections of the rudder frame. Consequently during preheating care had to be taken to preheat thoroughly the adjacent unfractured parts in order to offset the cooling strains later. The welds required a total of about 900 pounds of thermit.

The repair, made by the Robins Dry Dock and Repair Company, Brooklyn, N. Y., cost only $1,500 and required only about 4 days.

Approximate Stability Formulae

BY HEINRICH SCHULTZ, DR. ING.

Almost all usual methods of calculating stability by planimeter or integrator are rather complicated, and the time required is often out of proportion to the results obtained. What the naval architect needs is a short and simple method which will give him the angle of maximum stability, the maximum righting lever, the angle of vanishing stability, or the entire curve of righting levers with sufficient accuracy for practical purposes. Such a method has been developed in the author's treatise in "Shiffbau," December 15, 22 and 29, 1920, and follows in condensed form.

THE method of calculating stability outlined in the following is purely analytical and the formulae are based on the well-known values of BM and GM of initial stability and the shift of the CB from the upright position to 90 degrees inclination, expressed in rectangular co-ordinates n and p. The latter two values are easily obtained from the body plan, or they can be calculated in sufficient approximation by empirical formulae. When the fundamental data, viz., BM, GM, n and p, have been obtained, the curve of stability can be obtained in a few minutes by means of a slide rule.

The symbols used in the formulae are as follows:

B_o = beam of vessel.
H = depth of vessel.
D = draft of vessel.
b_o = function of beam.
δ = block coefficient.
α = coefficient of fineness of $L.W.L.$
$L.W.L.$ = load waterline.
f = freeboard.
f' = virtual freeboard.
K = keel point.
B = center of buoyancy in upright position.
B_{90} = center of buoyancy in 90-degree position.
B' = projection of B_{90} on centerline of vessel.
M = transverse metacenter in upright position.
G = center of gravity of vessel.
$n = BB'$.
$p = B_{90}B'$.
$q = p - n$.
ϕ = angle of inclination.
ϕ_m = angle of maximum stability.
ϕ_k = angle of vanishing stability.
$GZ\phi$ = lever of statical stability.
GZ_a = arithmetic average of all ordinates GZ.
$B'Z\phi$ = distance from B' to line of action of righting force.
$KZ\phi$ = distance from K to line of action of righting force.
$h\phi$ = lever of dynamical stability.
V = volume of displacement.
v = volume of one-half of vessel below $L.W.L. = \frac{1}{2}V$.
v' = volume of one-half of vessel above $L.W.L.$
z = $C.G.$ of v below $L.W.L.$
z' = $C.G.$ of v' above $L.W.L.$
s = $C.G.$ of v from $C.L.$
s' = $C.G.$ of v' from $C.L.$
e = $C.G.$ of middle line plane from $L.W.L.$
a = thickness of correcting layer $= (v - v') \div$ area of middle line plane.
A_a = positive area under statical stability curve.
A_b = negative area under statical stability curve.

Calculation of Angles of Maximum and Vanishing Stability and of Maximum Lever of Statical Stability

The angle of maximum stability, Φ_m, can be derived from the formula:

$$(1)\quad \sin^2 \phi_m = \tfrac{1}{2}\,\frac{GM+n}{BM}.$$

The range of stability or angle of vanishing stability, ϕ_k, can be derived from the following formulae:

$$(2)\quad \sin^2 \phi_k = \frac{GM+n}{BM} \text{ for angles up to 90 degrees}$$

$$(3)\quad = 90 + 120\,\frac{GZ_{90}}{BM} \text{ for angles up to 90 degrees and larger.}$$

The maximum lever of statical stability, GZ_{max}, can be obtained as follows:

$$(4)\quad GZ_{max} = p - n + GZ_{90}\sin\phi_m$$
$$= p - n + GZ_{90} \times 0.71\,\sqrt{\frac{GM+n}{BM}}.$$

Formulae (1), (2) and (4) include a certain margin of safety, whereas formula (3) gives very close results.

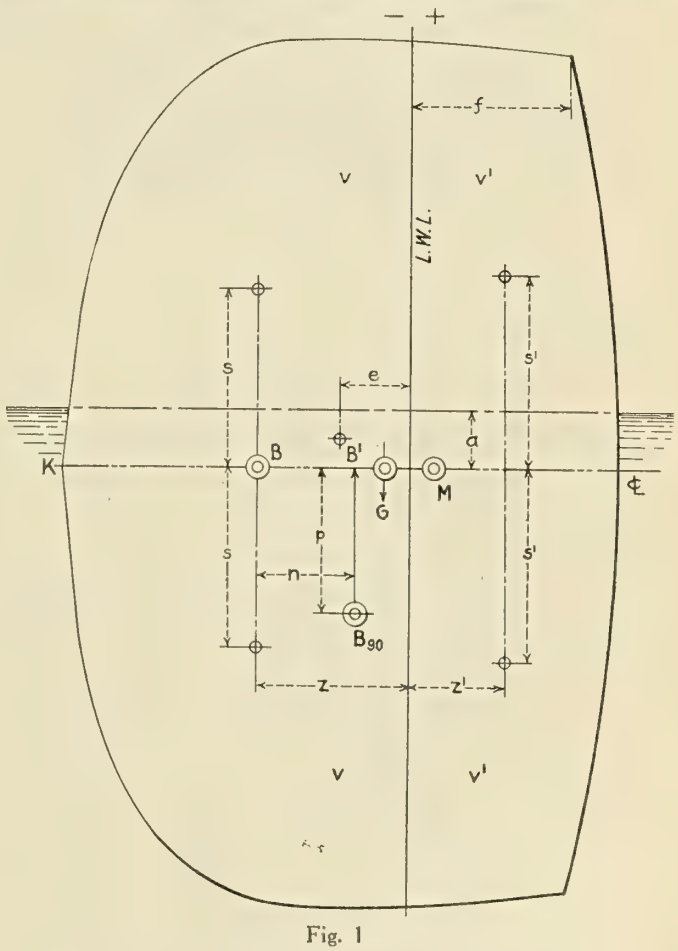

Fig. 1

Calculation of Righting Levers

The righting lever at any angle equals:

$GZ\phi = B'Z\phi \pm B'G \sin\phi.$
$B'G \sin\phi = GZ_{90}\sin\phi = (n - BG)\sin\phi.$
$GZ\phi = B'Z\phi + (n - BG)\sin\phi.$

The values of $B'Z$ can be obtained from the following formulae:

$$(5)\quad \text{When } \frac{BM-n}{q} \text{ is between 1 and 2}$$

$B'Z_{15} = 0.264\ (BM - n)$
$B'Z_{30} = 0.9q$
$B'Z_{45} = q$
$B'Z_{60} = q \sin 60° = 0.866q$
$B'Z_{75} = \frac{1}{2}q$
$B'Z_{90} = 0.$

COMPARISON OF STABILITY VALUES OBTAINED BY EXACT CALCULATIONS (R) WITH THOSE FROM FORMULAE 1 TO 6

No.	Type	Displ. Tons	GM	BM	BG	p	n	u — d = b	$GZ_{90} = u - BG$	Angle of Max. Stability R	Angle of Max. Stability Form 1	GZ Max. R	GZ Max. Form 4	Range of Stability R	Range of Stability Form 2	Range of Stability Form 3	Values of GZ 15° R	Values of GZ 15° F 5 & 6	Values of GZ 30° Form. 6	Values of GZ 30° R	Values of GZ 45° 5	Values of GZ 45° 6	Values of GZ 45° R	Values of GZ 60° 5	Values of GZ 60° 6	Values of GZ 60° R	Values of GZ 75° 5	Values of GZ 75° 6	Values of GZ 75° R	BM-n / p-n
1	Sailing Vessel	3,000	3.28	8.43	5.15	6.82	4.50	2.32	−0.65	38°	42°	2.04	1.87	81°	76.5°	80.7°	0.92	0.85	1.77	1.84	1.77	2.00	0.85	1.97	1.87	1.44	1.35	0.49	0.39	0.52	1.70
2	"	4,560	1.94	7.48	5.54	5.74	3.68	2.06	−1.86	32°	37°	0.89	0.95	59°	60°	60°	0.56	0.53	0.98	0.89	0.85	0.85	0.66	0.66	0.75	+0.03	−0.13	0.850	0.850	0.853	1.84
3	"	9,000	1.67	9.81	8.13	7.64	4.99	2.65	−3.14	26°	34°	0.95	1.28	55°	55.5°	51.5°	0.53	0.43	0.89	0.85	0.82	0.59	0.49	0.49	0.46	−0.49	−0.52	−1.80	−1.80	−1.80	1.82
4	"	10,500	1.74	9.35	7.61	8.40	6.23	2.17	−1.38	26°	40°	1.38	1.28	70°	67°	72.3°	0.69	0.46	1.21	1.31	1.31	1.38	1.25	1.25	1.18	0.75	0.56	0.49	−0.16	−0.33	1.52
5	Yacht "Jullanar"	153	3.28	4.30	1.02	3.84	3.31	0.53	+1.29	70°	60°	2.52	2.40				0.85	0.85	1.77	1.57	1.61	2.23	2.20	2.20	2.30	2.30	2.53	2.46	2.46	2.53	2.56	1.88
6	Cargo Steamer	1,940	1.48	6.40	4.92	7.05	5.90	1.15	+0.98	55°	48.5°	2.14	1.90				0.49	0.39	1.25	1.25		2.00	2.07	1.84	2.17	2.13	(1.84)	1.77	1.77	1.58	1.54	0.43
7	Cargo & Pass. Steamer	13,000	0.66	9.25	8.60	9.81	7.90	1.91	−0.70	48°	42°	1.77	1.44	74°	74°	81.1°	0.20	0.16	0.95	0.95		1.71	1.67	1.67	1.44	1.57	1.51	(1.08)	0.56	0.56	(0.26)	0.71
8	" " "	18,000	0.95	14.18	13.22	15.74	14.43	1.31	+1.21	50°	45°	3.25	2.53				0.36	0.39	1.44	1.41		2.85	3.08	2.53	2.99	2.99	2.95	(2.20)	1.84	1.97	(1.28)	0.11
9	" " "	50,000	1.97	25.70	23.74	27.14	22.72	4.42	+1.02	55°	43.5°	4.16	3.71	85°	78°	85.25°	0.62	0.75	2.49	2.33		4.23	4.17	3.68	3.81	3.81	4.17	(2.92)	1.90	1.97	(1.18)	0.68
10	Cargo Steamer	440	3.02	4.78	1.77	2.53	1.22	1.31	−0.55	38°	41°	0.92	0.95	75°	70°	76°	0.69	0.79	1.12	0.92	0.92	0.92	0.85	0.92	0.92	0.46	0.46	0.66	−0.03	0.00	+0.10	0.23
11	Cable Steamer	3,600	1.97	6.99	5.02	7.05	5.97	1.08	+0.95	60°	48.5°	1.97	1.81				0.62	0.53	1.35	1.44	1.44	1.90	1.80	1.80	1.87	2.00	1.77	1.61	1.51	1.51	1.51	0.94
12	Steam Yacht	540	1.21	4.33	3.12	4.07	3.15	0.92	+0.03	52.5°	45°	1.02	0.95				0.43	0.33	0.76	0.79	0.82	1.02	1.02	1.02	0.95	0.86	0.82	0.56	0.62	0.49	1.30
13	Steam Trawler	390	2.33	5.25	2.92	4.23	3.41	0.82	+0.49	40°	47°	1.15	1.18	63°	62°	63.7°	0.69	0.59	1.05	1.05	0.98	1.28	1.12	0.92	0.89	0.92	0.98	0.82	0.82	0.89	2.24
14	Canal Steamer	500	2.33	6.13	3.90	4.26	2.56	1.70	−1.34	38°	38.5°	1.08	0.89				0.39	0.39	0.85	0.89	0.79	0.98	1.05	0.98	0.89	0.89	0.92	0.95	0.79	0.63	−0.46	1.90
15	Fire Ship	300	1.51	4.40	2.89	4.00	3.38	0.62	+0.40	45°	47°	1.05	0.98				0.52	0.52	1.25	1.21	1.28	1.57	1.54	1.54	1.44	1.25	1.31	1.21	0.79	0.79	0.72	1.37
16	Surveying Steamer	650	1.94	7.97	6.03	7.45	6.03	1.42	0.00	45°	49°	1.54	1.41	64°	58.5°	57.5°	0.98	0.92	1.87	2.00	1.84	1.61	1.61	1.54	1.35	−0.03	+0.03	−2.26	−2.26	−2.29	1.77
17	Battleship	12,800	3.51	17.03	13.50	13.50	8.92	4.58	−4.58	35°	37°	2.04	1.84	58.5°	58.5°	53.5°	1.77	1.38	2.59	2.69	2.36	1.94	2.03	1.80	−0.52	−0.36	−0.29	−3.54	−3.45	−3.48	1.87
18	"	24,000	5.15	21.68	16.53	16.21	9.90	6.31	−6.63	32°	36°	2.69	2.43	56°	55°	51°	1.54	1.12	2.36	2.36	2.20	2.36	2.03	1.80	−0.52	−0.36	−0.29	−3.54	−3.45	−3.48	1.87
19	"	23,800	4.20	21.05	16.88	16.27	10.04	6.23	−6.84	32°	35°	2.40	2.30	55°	55°	63°	1.52	1.12	2.36	2.23	2.36	2.53	2.20	2.03	1.74	1.64	1.41	−0.66	−0.49	−3.74	−3.84	−3.71	1.77
20	Battle Cruiser	24,000	8.53	22.98	14.44	15.75	9.25	6.50	−5.19	34°	39°	3.54	3.35	63°	61.5°	63°	2.17	2.26	2.76	2.76	3.25	3.08	3.02	2.82	2.62	0.66	0.62	1.15	−2.17	−2.36	−1.94	1.70
21	"	26,000	9.51	23.12	13.62	15.80	8.99	6.81	−4.63	35°	39°	4.46	3.90	66.5°	63.5°	67°	2.43	2.53	4.33	4.46	3.84	3.77	3.77	3.58	3.58	1.41	1.21	1.10	−1.54	−1.54	−1.24	2.10
22	Cruiser	9,800	2.40	12.67	10.27	11.78	10.10	1.68	−0.17	40°	44°	1.54	1.57	87°	83°	88.4°	0.85	(0.62)	1.67	1.41	1.41	1.77	1.54	1.80	1.80	1.05	1.25	0.72	0.65	0.69	1.53
23	"	7,000	3.31	8.92	5.61	9.58	7.67	1.91	+2.06	55°	52°	3.80	3.54				1.08	(0.89)	2.20	2.23	2.76	3.61	3.51	3.05	3.97	3.97	3.81	3.71	3.31	3.21	3.35	0.66
24	"	6,500	3.61	11.55	7.94	9.67	6.85	2.82	−1.09	40°	42°	2.26	2.10	76°	72°	78.8°	1.05	0.95	2.00	2.17	2.00	2.30	2.26	2.07	2.07	1.51	1.64	1.51	0.36	0.13	0.03	2.10
25	"	5,500	3.61	11.32	7.71	11.48	9.84	1.64	+2.13	55°	50°	3.48	3.28				1.05	0.95	2.33	2.36	2.53	2.38	3.41	3.15	3.45	3.48	3.25	3.12	3.02	2.95	3.02	0.90
26	"	4,900	3.61	10.82	7.21	10.57	8.82	1.75	+1.61	55°	49°	3.05	2.92				1.15	0.95	2.30	2.23	2.36	2.76	2.95	2.85	2.95	3.05	2.89	2.89	2.56	2.46	2.46	1.15
27	"	3,100	1.94	7.74	5.80	7.28	6.63	0.65	+0.83	45°	47°	1.18	1.25				0.59	0.53	1.51	1.12	1.18	1.35	1.18	1.25	0.92	1.18	1.27	1.08	1.05	1.05	1.15	1.70
28	"	1,700	2.30	8.33	6.03	7.74	6.69	1.05	+0.66	45°	47°	1.57	1.54				0.72	0.62	1.48	1.38	1.28	1.64	1.58	1.48	1.28	1.38	1.48	1.18	1.05	1.18	1.16	1.56
29	Gunboat	1,100	1.74	8.10	6.36	7.48	6.46	1.02	+0.10	52°	45°	1.15	1.08				0.49	0.46	1.15	0.85	0.95	1.21	1.08	1.08	1.03	1.02	0.75	0.95	0.62	0.59	0.59	1.61
30	Torpedo Boat	530	2.92	7.25	4.33	5.74	4.46	1.28	+0.13	45°	45°	1.38	1.28				0.72	0.79	1.51	1.35	1.25	1.54	1.48	1.38	0.98	1.21	1.25	0.69	0.62	0.82	2.18
31	"	640	3.58	7.70	4.13	6.10	4.66	1.44	+0.53	45°	47°	1.97	1.84				0.95	0.95	1.77	1.67	1.54	1.97	1.94	1.80	1.48	1.48	1.71	1.15	1.05	1.25	2.11
32	Destroyer	800	3.38	7.31	3.94	5.67	4.23	1.44	+0.29	40°	45°	1.80	1.64				0.85	0.88	1.64	1.61	1.44	1.77	1.74	1.64	1.31	1.35	1.51	0.95	0.82	1.02	2.19
33	"	1,300	4.46	9.61	5.15	8.13	6.85	1.28	+1.70	50°	50°	2.70	2.59				1.15	1.18	2.40	2.07	2.03	2.69	2.62	2.49	2.23	2.36	2.59	2.17	2.17	2.36	2.15
34	"	1,300	2.95	9.01	6.07	7.94	6.50	1.44	+0.43	48°	46°	1.80	1.74	75°	75°		0.79	0.79	1.35	1.44	1.51	1.64	1.80	1.74	1.61	1.67	1.44	1.15	1.18	1.15	1.74
35	Sea-going Submarine	1,060	1.31	3.22	1.90	2.26	1.67	0.59	−0.23	32°	42°	0.43	0.43	78°	75°	81.4°	0.36	0.36	0.45	0.41	0.42	0.49	0.39	0.43	0.23	0.26	0.33	0.03	0.07	0.07	2.61

Note: All dimensions given are in feet unless otherwise marked.

(6) For any value of $\frac{BM-n}{q}$

$$B'Z_{15} = 0.264\ (BM - n)$$
$$B'Z_{30} = 1.766q - B'Z_{60}$$
$$B'Z_{45} = 0.48q\left(1 + 0.735\,\frac{p+n}{p}\right)$$
$$B'Z_{60} = 0.5\,p - 0.583\left(\frac{n}{p}\right)^3 BM$$
$$B'Z_{75} = 0.259\,p - 0.268\left(\frac{n}{p}\right)^3 BM$$
$$B'Z_{90} = 0.$$

Using formula (5), we get:

$$GZ_{60} = q \sin 60° + GZ_{90} \sin 60°$$
$$= \sin 60°\ (p - n + n - BG)$$
$$= 0.866\ (p - BG)$$
$$GZ_{75} = \tfrac{1}{2}q + GZ_{90} \sin 75°$$
$$= \frac{p-n}{2} + 0.966\ (n - BG)$$
$$= \frac{p+n}{2} - BG \text{ (approx.)}$$

From the foregoing the following approximations can be deduced:

(7) When $BG = n$, the range of stability is 90 degrees.

(8) When $BG = \frac{p+n}{2}$, the range of stability is at least 75 degrees.

(9) When $BG = p$, the range of stability is at least 60 degrees.

The above formulae hold good for all types of sea-going vessels, including battleships and submarines. The accompanying table shows a comparison of the results obtained by the above formulae and by exact calculations for 35 vessels.

CHECK ON FORMULAE (5) AND (6)

Formulae (5) and (6) may be checked as follows:

$$h_{90} = p - BG$$
$$h_{90} = \int_0^{\pi/2} GZ\,d\phi = \frac{A_a - A_b}{\text{base line}} \times \frac{\pi}{2} \text{ (see Fig. 2)}$$
$$= GZ_a \times \frac{\pi}{2}.$$

Then

$$p - BG = GZ_a \times \frac{\pi}{2},$$

provided p is obtained by exact calculation. GZ_a may be calculated by Simpson's rule.

CALCULATION OF n AND p

The importance of the n and p values for calculating stability makes it desirable to determine them quickly and, if possible, analytically. The following formulae have been found to give very good results:

(10) $$n = \frac{1}{V}\left[(vz + v'z') \pm e\,(v - v')\right]$$ (modified Attwood's rule).

For an ideal wall-sided vessel without sheer or camber, formula (10) becomes:

(11) $$n = \frac{D}{4}\left(\frac{f}{D}\left[\frac{1 + \delta/a}{\delta/a}\right] - \tfrac{2}{3}\left[1 - \delta/a\right]\right)$$

The expression on the right-hand side of formula (11) shrinks to $\frac{f}{2}$ when $\delta/a = 1$, and also for any value of δ/a, provided $\frac{f}{D} = \frac{2}{3}\,\delta/a$.

When $\delta/\alpha > 0.9$, n becomes approximately $\frac{f}{2}$.

When $\frac{f}{D}$ is somewhat greater or less than $\frac{2}{3}\,\delta/\alpha$, n differs but slightly from $\frac{f}{2}$.

For flush deck vessels with sheer and camber the virtual freeboard, f', is substituted for f.

$f' = 2v' \div$ area of water plane at a height of $\frac{f}{2}$ above *L.W.L.*

For practical purposes the formula for n may then be written:

$$(12)\quad n = \frac{f'}{2}.$$

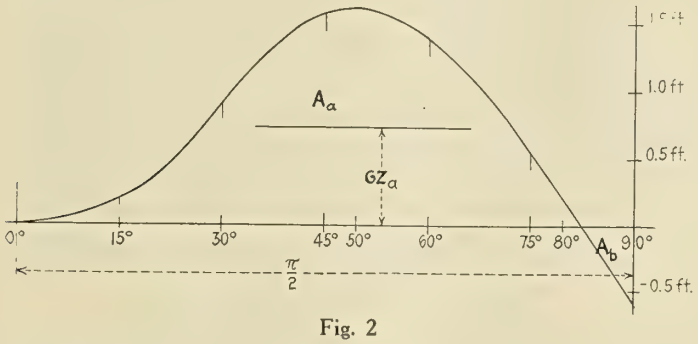

Fig. 2

The following table shows a comparison of the results obtained by exact calculation, from formula (12) and from formula (11a) [formula (11) with f' substituted for f]:

Type	f' Feet	D Feet	δ/α	f'/D $\frac{2}{3}\delta/\alpha$	n (11a)	n (12)	n Exact Calc.
Cargo steamer...	8.33	12.98	0.92	1.05	4.17	4.17	4.10
Cargo steamer...	12.53	25.69	0.90	0.81	6.20	6.26	6.30
Sailing ship.....	9.15	16.40	0.79	1.06	4.59	4.57	4.50
Sailing ship.....	6.88	22.32	0.83	0.56	3.15	3.44	3.22
Pilot steamer....	4.92	10.32	0.66	1.09	2.52	2.46	2.56

p can be calculated quite accurately by Moseley's rule, modified:

$$(13)\quad p = \frac{1}{V}\left[(vs + v's) - \frac{a}{2}(v - v')\right]$$

in which

$$s' = \frac{B_o}{2}\,\frac{a}{1+a}, \text{ (approximate)}$$

$$s = \frac{b_o}{3}\,[\tfrac{1}{2} + \delta/\alpha\,(1.10 - 0.10\alpha)],$$

$$b_o = \frac{B_o}{2}\,\frac{3\alpha}{2\alpha + 1}.$$

p can also be calculated approximately with relation to n, as follows:

$$(14)\quad p = \frac{b_o}{4}\,\frac{8n + \frac{D}{3}(1 - \delta/\alpha)}{D + 2n}.$$

The expression on the right-hand side of the formula is always somewhat greater than $\frac{2nb_o}{D + 2n}$, and for full vessels where $\delta/\alpha > 0.90$, formula (14) becomes very nearly:

$$(15)\quad p = \frac{2nb_o}{D + 2n}.$$

Formula (15) gives very good results.

EXAMPLE

Cargo steamer, well-deck type, with usual sheer:
448 feet by 54 feet by 25.7 feet draft.
Displacement = 13,500 tons.
$GM = 0.655$ feet; $BM = 9.240$ feet; $BG = 8.585$ feet.
$\delta = 0.761$; $\alpha = 0.844$; $\delta/\alpha = 0.902$.

The volume $2v'$ was calculated as 339,800 cubic feet, and the area of the water plane at a height of $\frac{f}{2}$ above the *L.W.L.* was 21,300 square feet. From formula (12):

$$n = \frac{f'}{2} = \tfrac{1}{2}\,\frac{339{,}800}{21{,}300} = 7.97 \text{ feet.}$$

An exact moment calculation of the body plan gives $n = 7.90$ feet.

From formula (15):

$$p = \frac{2nb_o}{D + 2n} = \frac{2 \times 7.97}{25.7 + 15.94} \times \frac{54}{2} \times \frac{2.532}{2.688} = 9.75 \text{ feet.}$$

$$q = p - n = 9.75 - 7.97 = 1.78 \text{ feet.}$$

$$\frac{BM - n}{q} = \frac{9.24 - 7.97}{1.78} = 0.71.$$

Since $\frac{BM - n}{q}$ is less than 1, formula (6) must be used for calculating righting levers.

$GZ_{90} = B'G = n - BG$
$= 7.97 - 8.585 = -0.615$ feet.

$GZ\phi = [B'Z\phi] + [B'G \sin \phi]$.

$GZ_{15} = [0.264\,(9.24 - 7.97)] + [-0.615 \times 0.259] = 0.176$ feet.

$GZ_{30} = [1.766 \times 1.78 - 1.925] + [-0.615 \times 0.500] = 0.916$ feet.

$$GZ_{45} = \left[0.48 \times 1.78\left(1 + 0.735\,\frac{9.75 + 7.97}{9.75}\right)\right] + [-0.615 \times 0.707] = 1.560 \text{ feet.}$$

$$GZ_{60} = \left[0.5 \times 9.75 - 0.583\left(\frac{7.97}{9.75}\right)^2 9.24\right] + [-0.615 \times 0.866] = 1.392 \text{ feet.}$$

$$GZ_{75} = \left[0.259 \times 9.75 - 0.268\left(\frac{7.97}{9.75}\right)^3 9.24\right] + [-0.615 \times 0.966] = 0.575 \text{ feet.}$$

$GZ_{90} = [0] + [-0.615 \times 1] = -0.615$.

The results may be checked as follows:

GZ_0	0	½	0
GZ_{15}	0.176	2	0.352
GZ_{30}	0.916	1	0.916
GZ_{45}	1.560	2	3.120
GZ_{60}	1.392	1	1.392
GZ_{75}	0.575	2	1.550
GZ_{90}	−0.615	½	−0.307

$GZ_a = 6{,}623 \times \frac{2}{3} \times 1/6 = 0.736$ feet.

$$h_{90} = 0.736\,\frac{\pi}{2} = 1.156 \text{ feet.}$$

$p - BG = 9.75 - 8.585 = 1.165$ feet.

These two values check fairly well.

The stability curve can be plotted in the usual manner, using the above values of GZ as ordinates. From this curve

(*Continued on page* 487.)

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WE GUARANTEE that of this issue 6,500 copies were printed; that of these 6,500 copies 5,159 were mailed to regular paid subscribers, 326 were provided for counter and news company sales, 260 were mailed to advertisers, 85 were mailed to employes and correspondents, and 670 were provided for new subscriptions, samples, copies lost in the mail, and office use; that the total copies printed this year to date were 45,700—an average of 7,617 copies a month.

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A Real Administrator Necessary

THE manner in which the Shipping Board has functioned in the past with one or more commissioners assigned to the direction of certain departments, such as marine insurance, construction and operation, has probably been one of the chief reasons why big business men have shown a reluctance to accept the chairmanship of that board. It is a well-known saying that "a board is wooden," and it is only natural for a man who has made a success as a real business administrator to hesitate when asked to undertake the responsibility of the direction and development of our merchant marine where there is so much opportunity for interference with his plans by the other commissioners appointed from sectional regions and more or less dominated by sectional politicians.

Our merchant marine is of the greatest national importance both in peace and in war, and the chairman of the Shipping Board should be responsible for the administration of our shipping policies to the President alone. The other commissioners who should perform the services of counsellors or advisors, as in any well-regulated business, had far better be chosen for their knowledge and experience in marine matters than from the fact that they reside in a certain section of the country.

It is true that there are some judicial functions, such as the adjustment of claims, fixing of compensation for property commandeered in the war, determining rates and regulations, hearings of complaints, etc., where the Board can advantageously act as a unit, but the active administration of shipping policies, the establishment of adequate trade routes, the sale of ships and supplies, the daily problems occurring in connection with operating the fleet until it is sold and the decisions of such questions as will vitally affect the success or failure of our merchant marine should be under the control of one man, and that man should be the best that the country affords.

Protection for Shipping

MARINE ENGINEERING has consistently advocated that immediate action be taken to make possible the enforcement of the discriminatory custom duties, tonnage dues and preferential rail export rates specified in the Merchant Marine Act. Outside of the fact that a law on the statute book should be either enforced or repealed this magazine has repeatedly pointed out that the manufacturing and agricultural industries are protected while shipping is not.

The shipyard must pay higher wages for labor and higher prices for materials and equipment on account of the tariff and, in order to compete with foreign shipyards, some form of subvention must be received. The public will invest in shipping securities only when it sees a fair chance of a reasonable return and adequate American shipping cannot be developed without capital.

The Merchant Marine Act, by placing a premium on American-built vessels, aids shipbuilding as well as shipping. While other helpful shipping legislation is contemplated and should be enacted, the fact remains that the Government will have to charter its ships at rates that really mean a large subsidy to the operators or put into effect protection equivalent to that provided in the Jones Act. Why not give it a trial?

Shipping Is the Answer

HOW does it happen that the United States with an overabundance of money, food, cotton, copper, coal, steel and manufactured products, in fact most everything that other countries sadly lack, can be anything but prosperous? Is it not because we are afraid to ship our surplus products to other countries except on a cash basis F. O. B.? While it is considered to be a fundamental fact that one nation cannot be prosperous while others are depressed, a condition where such a state could not be remedied would only obtain where over production existed all over the world.

A movement of our surplus products to Europe would not only increase the demand for American labor and decrease the domestic price of our goods but it would also, and particularly in the case of raw materials, furnish the means of starting production in less fortunate countries. The English government has led the way in the solution of this problem by guaranteeing their manufacturers 80 percent of the invoice price of their exports. She has bought goods from us on a cash basis and sold them to other countries on long term loans and in the meantime her merchant marine has been getting a larger and larger percentage of the carrying trade.

History will show that maritime nations are the most successful because the prosperity of an industry is assured when there is a world-wide assimilation of its products. Each new market brings greater buying power and larger consumption. Larger consumption through quantity production reduces prices and low prices increase prosperity and make it possible to pay good wages.

American producers, be they engaged in manufacturing, mining or agriculture, must be made to realize the possibilities of our merchant marine. Agriculture and mining not only have a surplus to export, but a large percentage of their domestic trade is in the form of raw material for the manu-

facturing industry and when a surplus of manufactured goods accumulates that cannot be disposed of there is a back up all along the line.

The practical, profitable and patriotic thing that we should do is to develop our export market to the fullest extent by controlling our ocean freight through the employment of American vessels and including in the sales price of our exports the cost of transportation to their destination. In no other way can we know our markets or what is the comparative price of our competitors' goods. Are we hesitating again while even Belgium, which stood the gaff of the war, is making arrangements to supply Roumania with vast supplies of clothing on a five-year credit?

Naval Policy

IN another column of this issue a résumé is given of a recent meeting of the Institution of Naval Architects, an organization that is national in character and unofficially in close relation to the British government. At the annual dinner in response to the toast of The Royal Navy a statement was given by the First Lord of the Admiralty which must be considered to be authoritative.

In this statement two points of great interest to us were made, first, that the capital ship is and will remain the best unit of seapower and that it will play in the future the same vital part in naval warfare that it has done in the past; the second point is that the British government accepts with equanimity the intention of the United States to have a navy equal to that of any other power. It is worth while to quote the words of the First Lord of the Admiralty as follows:

"That is a claim to equality which this country [England] has never accepted in the past and never would accept save in connection with the great English-speaking nation which has sprung from our loins, and which must ever hold a special place in our regard and confidence. We have, therefore, twice affirmed in the most formal way possible our acceptance for the future of a one-power standard; that is, that our Navy shall never be inferior in strength to that of any other Power."

Superheaters

IT is surprising in view of the emphatic necessity for economy in the operation of our merchant marine that high degree superheaters have not been more generally installed on American ships. Particularly is this true in the case of turbine driven vessels, and Mr. Robert Warriner, chief engineer of the Bethlehem Shipbuilding Corporation, in his recent paper read before the May meeting of the Society of Naval Architects and Marine Engineers calls attention to the fact that, although the installation of turbines has shown a marked gain in economy over the reciprocating engine in actual service, these results could have been increased by the use of superheated steam with very little increase in the cost of the turbines. He states that "practically all that would be needed would be to make the high pressure end of the casing of cast steel instead of cast iron."

That the naval engineers of Japan are not unaware of the economy of utilizing the gases of combustion for superheating with the consequent saving in the amount of both fuel and water used is attested by the fact that the specifications for the 20,000-ton fuel ship recently awarded to the New York Shipbuilding Corporation direct that the boilers shall be equipped with superheaters capable of attaining a superheat of 200 degrees Fahrenheit. Of still greater import is the fact that the Cunard line, which has a most conservative reputation, is installing high degree superheaters in all its new passenger ships. America having led in the adoption of labor-saving devices should not allow other countries to lead in mechanical economizers.

Although President Harding clearly indicated in his message to Congress that America was determined to establish its merchant marine and that such aid as was necessary would be given, we take it, however, that this aid is not meant to cover wastes that can be avoided and we are even more certain that Congress will not be inclined to help the Shipping Board or private operators if they do not show a keen disposition to help themselves.

The Gas Turbine

EVER since the steam turbine became a commercial success, the minds of engineers and inventors have turned to the gas turbine with the hope of winning the same increase in economy that the gas engine has shown over the steam engine. It is fair to say that the best minds have turned away again, appalled by the difficulties of the problem.

Let us consider some ideas connected with the gas turbine. A naïve idea is to put explosive materials into a receptacle, explode them and let the resultant gases flow through the nozzles of a turbine. If we could afford to use T. N. T. or some other solid explosive material, so simple a solution of the problem might be possible; but unfortunately one of the elements for the explosion or combustion is atmospheric air; indeed it is the chief element both in volume and in weight. The only way of putting air into the combustion chamber is first to compress it in an air compressor, usually driven by steam. That is what is done to the charge of the torpedo in naval service. In the torpedo is a bottle of highly compressed air which flows into a chamber where an alcohol lamp burns; the hot gases drive a turbine on the propeller shafts. This is to date the only practicable gas turbine. To be sure, the leading idea is to warm the air and keep it from freezing up, but the result is a real gas turbine, though an inefficient one. The air compressor which is an indispensable part of the cycle of operations is driven by steam and kept aboard the ship which discharges the torpedo. The expense of the air is trivial compared with that of the torpedo, so why worry about economy?

Current literature reports the first *commercial* oil turbine, which is of course to inaugurate a new era in marine engines. This turbine is built by Messrs. Thyssen & Company at Muelheim, Germany, and is reported to consist of a combustion chamber and a turbine with specially heat treated electric steel blades. *Air is compressed in a separate air compressor driven by a steam motor.* The explosion pressure is limited to 205 pounds to keep the temperature within manageable limits, and the exhaust gases generate steam to drive the compressor. One's first impression is bewilderment and then a desire to see the heat balance of the combination. If it

can be accepted as the beginning of the solution of the gas turbine, then it appears that many of the troubles of the inventors are ahead.

So much has been done with special steels in recent years that we may provisionally accept the report that the special heat treated electric steel blades have operated satisfactorily at the temperatures to which they are subjected and yet we may wonder what the gases will do to the blades when the oil turbine is worked up to compete with the Diesel engine with its high pressure, high temperature and high economy. What material can be found that will stand such a combination of high peripheral speed, high temperature and erosion?

But why should we have a steam driven air compressor? Why not turn the steam generated by the exhaust gases into the turbine along with the gas from the combustion chamber? Why not gear the compressor onto the turbine? Why not have a centrifugal compressor? If a turbine can derive power from gases flowing through it, why should not a turbine reversed and driven at the proper speed draw in air and compress it? The ideal gas (or oil) turbine should be self-contained, carry its compressor on its main shaft, have an expansion comparable with that of the hot bulb engine and work at comparable temperatures. There is trouble enough ahead for the inventor who works toward such an ideal.

Immigration in American Vessels

FORESEEING the effect of restricted immigration on ocean-going passenger ships, Senator Jones has introduced a bill in the Senate limiting the transportation of immigrants to vessels flying the American flag. This bill must be regarded as a prohibitory rather than a discriminatory measure and, considering the trouble we are having in even starting the procedure that is necessary to modify existing treaties so that we may favor American ships with such preferential tariff rates that they can operate on the American standard of wages and living in competition with foreign vessels, it does not seem probable that this measure could be practically enforced should it become a law.

Our shipping policy, as we understand it, is to secure a reasonable share of commerce for American vessels; in other words to live and to let live. Although the United States might be able, because of its present financial position as compared to that of other countries, to so heavily subsidize American vessels that they could get all the business, such a policy would undoubtedly be detrimental morally and financially in the long run. The same would also be true of such drastic legislation.

On the other hand, if this bill restricted the immigration of foreigners to vessels of the country from which they embark and of the United States, it would not conflict with treaty provisions regarding direct trade. Such a law may be necessary if it is found that the passenger carrying trade between this country and another is monopolized by the ships of a third nation. Again, if immigration is restricted and companies operating both American and foreign vessels should favor their foreign ships by withdrawing the American vessels and placing them in the coastwise trade or in competition with established American lines, then such legislation may be necessary from the standpoint of self defense.

Ship and Sail on American Vessels

THE Shipping Board has entered into an advertising campaign to educate the shippers of this country on the advantages of shipping and sailing in American vessels. Undoubtedly the exporters and importers who travel back and forth across the ocean will favor those shipping lines with which they are familiar and no country can expect to get its share of business for its freight vessels if it ignores the importance of the passenger trade.

Recently complaint has been made that not only shippers but prominent Americans, including those in the employ of the Government, are traveling on British lines. The statement has been made that equivalent American ships are available, but this is not so. There are no *Aquitanias* or *Olympics* in the American service. We have chosen to let the *Leviathan* rot at her pier and have delayed the reconditioning of the *George Washington, America* and other German passenger ships, which could put up a first class service, while other countries have established new lines and enlarged their fleets.

American passenger liners are needed but they will not be forthcoming until the operating companies are assured that there is a chance of running them successfully in competition with foreign lines. The Shipping Board must recondition and charter its vessels on such terms as will make this possible and protection equivalent to that provided in the Jones Act must be obtained before new passenger ships will be ordered from American yards.

Shipbuilding Sustains Steel Corporation

THAT the earning power of the Bethlehem Steel Corporation has been sustained by its shipbuilding activities is evident from a comparison of that company's recent dividend action and the reports of such concerns as the Lackawanna and Republic steel companies. While it may be surprising for some people to learn that shipbuilding has bolstered up a great steel concern in times like these, yet even a casual examination of the reasons why Bethlehem still finds this industry profitable should be convincing.

Although the customary reports from the classification societies and other sources on the amount of work on hand in the shipyards usually fail to include the warships, the present naval program is a most important factor and in the case of Bethlehem it is the source of a very large amount of work. In addition to this, the corporation is building several large tankers and five ore-carrying vessels of 20,000 tons deadweight capacity, which, altogether, according to President E. G. Grace, is sufficient to keep the shipyards at Fore River, Sparrows Point and San Francisco, operating at full capacity for the remainder of the year.

While the shipyards have been a source of direct profit, incidentally, at a time when profits are highly desirable, they are also contributing work to the steel corporation by supplying orders for steel, armor, iron ore, coal and coke, which are all Bethlehem products. Important as the construction of these vessels is to Bethlehem, the ships themselves and the American merchant marine are still more valuable to the whole country as a means of creating markets for the nation's surplus products.

Approximate Stability Formulae

(*Concluded from page* 483.)

the angle of maximum stability, the greatest lever, and the range of stability can be determined.

These values can also be approximated by means of formulae (1) to (4):

(1) $\sin^2 \phi_m = \frac{1}{2} \frac{0.655 + 7.97}{9.24} = 0.467$;
$\sin \phi_m = 0.683$; $\phi_m = 43°$.
(The GZ curve gives $\phi_m = 50°$.)

(2) $\sin^2 \phi_k = 2 \times 0.467 = 0.934$;
$\sin \phi_k = 0.966$; $\phi_k = 75°$.

(3) $\phi_k = 90 - 120 \frac{0.615}{9.24} = 90 - 8 = 82°$.
(The GZ curve gives $\phi_k = 82°$.)

(4) $GZ_{max} = 1.78 - 0.615 \times 0.683 = 1.36$ feet.
(The GZ curve gives 1.60 feet at 50°.)

Cross Curves of Stability

For calculating the cross curves showing the righting levers with respect to the axis through the keel point, K, for various drafts and displacements, the values $B'K \sin \phi$ must be added to the calculated values of $B'Z\phi$ instead of $B'G \sin \phi$.

$$KZ\phi = B'Z\phi + B'K \sin \phi.$$

Repeating the calculation for a new draft, D_2, differing somewhat from D, the values of n_2 and p_2 can be obtained quite closely for full vessels, as follows:

$$n_2 = n - \tfrac{1}{2}(D_2 - D).$$

$$p_2 = \frac{n_2}{n} p.$$

The $KZ\phi$ values can be plotted in the usual manner, the results obtained by the above method being sufficiently accurate for practical purposes.

Stability Numbers

The expression $\frac{GM + n}{BM}$ in formulae (1), (2) and (4) as an abstract number seems to be well adapted for judging the stability of a vessel.

When $\frac{GM + n}{BM} = 1$, the vessel becomes unstable at 90 degrees.

When $\frac{GM + n}{BM} = 0.75$, the vessel becomes unstable at approximately 60 degrees.

Figures of this kind may be termed "stability numbers," since they qualify vessels with respect to their stability.

Suppose a vessel's requirements are: In the full load condition the virtual freeboard, f', shall be such that the range of stability covers 60 degrees with a minimum initial stability ($GM = 0$). Then we may write:

$$\frac{0 + n}{BM} = 0.75.$$

With $n = \frac{f'}{2}$, the required freeboard, f', equals:

$$f' = 1.5BM; \quad \frac{f'}{BM} = 1.5.$$

For very full vessels with $BM = \frac{B_o^2}{12D}$, we get:

$$\frac{Df'}{B_o^2} = \tfrac{1}{8}.$$

When the virtual freeboard, f', of a modern cargo steamer is such that $\frac{Df'}{B_o^2} = \frac{1}{8}$, further stability calculations may be unnecessary.

A good average for cargo or passenger steamers is:

$$\frac{f'}{BM} = 1.$$

The simple relation, $f' = BM$, seems to give satisfactory stability conditions at sea.

NEW BOOKS

JOHNSON'S STEAM VESSELS, 1921. Twelfth edition. Size, 8⅝ by 4⅜ inches. Pages, 432. New York, 1921: Eads Johnson, M. E., Inc.

When this annual publication made its initial appearance in 1910, and for several subsequent years, it contained only a list of steam vessels in New York harbor. In the present edition the scope of the book has been widened so that the list covers steam vessels on the Atlantic, Gulf and Pacific coasts and on the Great Lakes. It gives in such form as to be convenient and instantaneously available the owner, name, age, material, type, hull dimensions, tonnage, engine and boiler dimensions and classification society of practically every steam vessel of American registry.

EXTRACTS FROM RULES. American Bureau of Shipping. Size, 5½ by 8½ inches. Pages, 38. New York, 1921. American Bureau of Shipping.

This pamphlet contains two sections of the rules of the American Bureau of Shipping which are new. They are: Section 36, covering internal combustion engines, which supersedes Section 36 of the previous issues of the rules; and Section 40, covering materials for machinery, boilers and piping, which supersedes Sections 40, 41 and 42 of the previous issues of the rules. Of special interest in the rules for internal combustion engines is the formula for determining the diameter of crankshaft, the derivation of which was discussed in a previous issue of MARINE ENGINEERING. The rules for materials for machinery, boilers and piping cover boiler material, steel, iron and bronze castings, steel and iron forgings, lap welded and seamless steel pipes, copper and brass plates, shapes, tubes and pipes.

STEAM BOILER ENGINEERING (Helios). Twenty-seventh edition. Size, 6 by 9 inches. Pages, 639. Illustrations, 423. St. Louis, Mo., 1921: The Heine Safety Boiler Company.

"Helios," which was first published by the Heine Safety Boiler Company in 1893, under the direction of the late Col. E. D. Meier, former president of the American Society of Mechanical Engineers and former president of the American Boiler Manufacturers' Association, now appears in new form and under a new name. Furthermore, the contents of the book have been completely revised and enlarged so that the present edition may be said to be entirely new. Briefly, it summarizes the latest commercial developments in boiler plant practice. It is in reality a handbook on boiler practice covering the theory of steam generation, the design of boilers, furnaces, chimneys, piping, auxiliary layouts and giving instructions for testing and operating boilers in accordance with the most approved methods. Although the book deals chiefly with stationary boiler installations, occasional reference is made to marine installations, especially in connection with such subjects as boiler settings.

Questions and Answers for Marine Engineers

Inquiries of General Interest Regarding Marine Engineering and Shipbuilding Will Be Answered in this Department

CONDUCTED BY JAMES L. BATES

This department is maintained for the service of practical marine engineers, draftsmen and shipbuilders. All inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given permission to do so.

Transporting Oil in Wooden Ships

Q. (1120).—I would like to know the feasibility of transporting fuel oil of 24 to 28 degrees Baumé in bulk in direct contact with a wooden hull in good condition, with a view to omitting steel tanks in a wooden schooner to carry oil in bulk and equipped with semi-Diesel type engines.
R. G. W.

A. (1120).—The information which you furnished is really not in sufficient detail to enable the proper answer to be made, even were the experience on this particular line wide enough to warrant a definite expression of opinion. In handling bulk oil care must be given to provide safety from fire, oiltightness and adequate stability of the vessel itself. There are in addition miscellaneous features, such as filling and discharge connections, cleaning, etc., but these are matters of detail.

It has been found that the fitting of large internal tanks, such as would be formed by the inner skin or ceiling of a wooden vessel, leaves inaccessible pockets in which dangerous gases may readily form. This objection would of course be largely avoided, if the vessel which you have in mind is not fitted with a wooden ceiling and the oil therefore allowed to come right out against the inner surface of the outer planking.

In wooden ships the planks are bound only indirectly to each other by means largely of their attachment to the frames. There is, therefore, no real continuity of structure. The longitudinal bending forces exert a strong tendency to make the planks slide lengthwise relative to each other. The friction of the calking between the planks helps somewhat to counteract this and provide rigidity and strength in the structure, but when the calking begins to give the hull strains and alters shape with comparative ease, especially when the vessel is old. In view of the above, considerable loss from leakage, due to the vessel's working in a seaway, might be expected, particularly where the oil is allowed to come right out to the vessel's outer skin and where the oil level within the compartment is considerably higher than the surface of the water outside the ship.

Whenever oil is carried in compartments a proper subdivision, both transverse and longitudinal, must be fitted in the vessel's hold so as to insure her stability. As you are doubtless aware, this generally results in a centerline and numerous transverse bulkheads in the case of the ordinary oil tanker.

Because of the foregoing, it would appear that the fire risks to be anticipated, the loss of oil during rough passage and the expense of converting the vessel for oil carriage would not warrant an attempt to utilize her in the manner suggested.

In case it was your intention to carry fuel for the vessel's own engines, rather than as bulk cargo, it is believed that an installation of steel tanks would, through a period of years, amply justify their initial cost. In this connection your attention is invited to the *Shipbuilding Cyclopedia,* 1920 edition, published by the Simmons-Boardman Publishing Company, of New York, in which certain wooden motor ships, recently designed by the firm of Cox and Stevens, New York, carry fuel oil in a number of small steel tanks. Also in MARINE ENGINEERING of February, 1921, you will find a short description of the so-called Ferris type of wooden ships fitted with oil burning boilers which also carry fuel oil in steel tanks. If such tanks are properly made and so installed as to be readily accessible, they afford, in the opinion of the writer, the best means of stowing oil for bunker purposes on board wooden vessels.

Crankshaft and Jib Crane Problems

Q. (1123).—(*a*) Given an 1,800 horsepower triple expansion engine, operating at 80 revolutions per minute, it is required to find the size of the crankshaft at the after side of the after crank. This must be found from first principles, and no formula as found in text-books may be used; also show position of cranks when maximum effort is exerted. This is a question given by the Canadian Government for their Civil Service examination. (*b*) In a jib crane a load of 5½ tons is suspended at the end of the jib. If the jib is 16 feet 4 inches long and the horizontal stay is 7.25 feet long, find the load on the jib and stay.
W. P. C.

A. (1123).—(*a*) Assumptions: Same power developed in each cylinder; length of stroke, 40 inches; high pressure cut off at 70 percent; cranks placed at angles of 120 degrees; effect of inertia neglected; distance between bearings for crank shaft journal brasses, 30 inches.

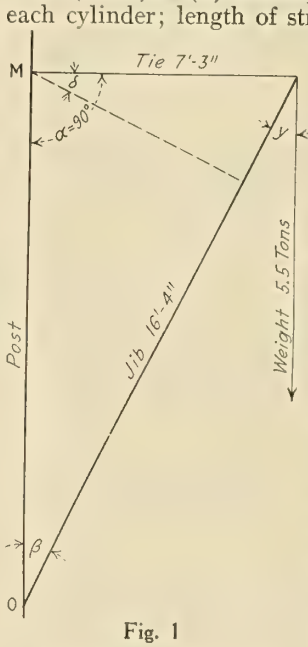

Fig. 1

These assumptions are in accordance with good practice for an engine of the above characteristics suitable for use in an ordinary cargo vessel.

The cross section of the crank shaft at the point stipulated must be of such size as to transmit the maximum turning effort of all three cylinders combined. It is necessary, then, to find first the value of this maximum turning effort and second the size of the shaft required to transmit it.

If a constant force were applied to the crank pin tangentially to its path, the work done per revolution would be

$$F \times \frac{2\pi L}{12},$$

where F is the force and L the length of the crank in inches.

Work done per minute =

$$F \times \frac{2\pi L}{12} \times R,$$

R being the number of revolutions per minute. $F \times L$ is the twisting moment continuously applied and the work done per minute is equal to I. H. P. × 33,000.

Then

$$I.H.P. \times 33{,}000 = F \times L \times \frac{2\pi}{12} \times R,$$

and mean twisting moment =

$$F \times L = \frac{I.H.P.}{R} \times \frac{33{,}000 \times 12}{2\pi} = \frac{I.H.P.}{R} \times 63{,}000.$$

In this case, the mean twisting moment for the engine =

$$\frac{1{,}800}{80} \times 63{,}000.$$

Investigation has shown that for a triple expansion engine having a cut off at 0.7 the ratio of maximum to mean twisting moment is 1.33. Maximum twisting moment becomes then:

$$\frac{1{,}800}{80} \times 63{,}000 \times 1.33 = 1{,}883{,}000 \text{ inch pounds.}$$

From this the maximum turning force on the after crank pin is:

$$\frac{1{,}883{,}000}{20} = 94{,}150 \text{ pounds.}$$

The stress in the cross section of the crankshaft results from the simultaneous application of the maximum twisting moment and a bending moment due to the force exerted by the connecing rod, a concentrated load, acting upon the crankshaft assumed to be a fixed ended beam.

This bending moment is:

$$\frac{94{,}150 \times 30}{8} = 353{,}000 \text{ inch pounds.}$$

The maximum equivalent twisting moment is found in the usual manner and is:

$$353{,}000 + \sqrt{353{,}000^2 + 1{,}883{,}000^2} = 2{,}268{,}000 \text{ inch pounds.}$$

On the basis of a solid shaft the diameter is found as follows:

Maximum twisting moment =

$$\frac{p_s I_p}{y},$$

in which p_s is the allowable working stress per square inch of material, I_p is the polar moment of inertia, and y is the radius of the shaft cross section.

$$I_p = \frac{1}{2}\pi r^4 = \frac{1}{32}\pi d^4,$$

in which r and d are respectively the radius and diameter of the shaft section.

$$y = \tfrac{1}{2} d.$$

The above expression for maximum twisting moment then becomes

$$T = \frac{p_s \pi d^3}{16} \text{ and } d = \sqrt[3]{\frac{T \times 16}{p_s \times \pi}} \text{ or } d = \sqrt[3]{\frac{T}{p_s}} \times 5.1.$$

If now we accept a working stress p_s of 6,000 pounds per square inch, we have

$$d = \sqrt[3]{\frac{2{,}268{,}000}{6{,}000}} \times 5.1 = 12.45 \text{ inches.}$$

If we allow a value of 8,000 for p_s, we have

$$d = 11.3 \text{ inches.}$$

The position of the cranks when maximum effort is exerted is dependent upon several different factors (mentioned below). But the information furnished is insufficient to make possible a satisfactory answer.

First.—The pressure of the steam ordinarily varies greatly at different parts of the stroke.

Second.—This varying pressure is transmitted to the crankpin by a connecting rod which changes its angle relative to the axis of the cylinder constantly throughout the length of the stroke.

Third.—An unequal distribution of power in the different cylinders frequently exists.

Fourth.—The effective turning effort upon the crank depends upon the weights and velocities of the various reciprocating parts as well as upon the variables previously mentioned.

In general the greater the number of cranks the more uniform the turning effort and twisting moment.

In order to ascertain the position of cranks at the time of maximum effort, in the present case, theoretical indicator cards would have to be assumed and a curve of twisting moment prepared for each crank, proper allowance being made for the effect of reciprocating parts. A curve of combined twisting moments could then be plotted and the points of maximum moment located thereon. This is a somewhat laborious operation and, considering the assumptions necessary, is believed to be unwarranted in the present case. Such diagrams are, however, worked out in

"Marine Engineer's Hand Book"—Sterling, page 934 to 937 inclusive.

"Manual of Marine Engineering"—Seaton, pages 182 to 184 inclusive.

"The Steam Engine"—Holmes.

(*b*) In Fig. 1 angle $\alpha = 90$ degrees (as tie is horizontal and the post is assumed vertical). Also angle β = angle γ = angle δ, from well known geometrical relationships.

Then

$$\sin \beta = \frac{7.25}{16.33} = .44397,$$

and angle

$$\beta = 26° \; 21' +.$$

Taking moments about O, the tension in the horizontal tie =

$$T = \frac{5.5 \times 7.25}{16.33 \cos \beta}.$$

Whence T = 2.73 tons (approximately).

Then taking moments about M, the crushing load in the jib =

$$C = \frac{5.5 \times 7.25}{7.25 \cos \delta}.$$

Whence $C = 6.14$ tons (approximately).

The above solution ignores the weights of the jib, tie, etc.

EDITOR TO AID HOOVER.—Frederick M. Feiker, vice-president and chairman of the editorial board of the McGraw-Hill Company, New York, has been granted a leave of absence to accept an appointment as assistant to the Secretary of Commerce. Mr. Hoover has divided the bureaus of the Department of Commerce into two parts. Assistant Secretary Huston will supervise the bureaus relating to navigation and fisheries, while Mr. Hoover will give his personal attention to the bureaus of foreign and domestic commerce, standards and census. Mr. Feiker will directly assist Mr. Hoover in the expansion of these bureaus as aids to business.

The immediate problem is to find out what kind of facts and figures industry needs from the government by means of a series of conferences with the representative men of industry. Having organized the department to function according to requirements, the next problem is to devise an adequate system of clearing the collected data back to business. Mr. Feiker's background of engineering training, viewpoint on the needs of industry and sense of publicity should be of unusual service in the furtherance of Mr. Hoover's plans.

PERSONAL MENTION

JUAN SOLDEVILLA, manager of the marine department of the Allianza de Santander, Barcelona, Spain, has been appointed surveyor for the American Bureau of Shipping. He graduated from the engineering department of Barcelona University in 1898, and from E. S. B. School, Liege, Belgium, in 1900. Since then he has carried on the study of shipbuilding and the practice of naval architecture at the Arsenol Civil of Barcelona.

D. C. YOUNG, for the past nine months chief surveyor in charge of the Seattle and Portland offices of the United States Bureau of Survey, has been appointed representative of the American Marine Insurance Syndicates at San Francisco, Cal. Born in Govan, Scotland, Mr. Young served his apprenticeship in engineering with the Smith Dry Dock Company, Ltd., on the Tyne, England. Subsequently he had sea-going experience in various grades, including that of chief engineer. Mr. Young came to the United States in 1909, and is now a naturalized citizen of this country. For about four and a half years previous to taking charge of the Seattle and Portland offices of the United States Bureau of Survey, Mr. Young was general manager of the Hanlon Dry Dock & Shipbuilding Company, Oakland, Cal.

D. C. Young

TRUMAN A. GAMON and A. HAROLD JANSSON have formed a partnership as naval architects and ship surveyors with offices at 50 Union Square, New York.

Mr. Jansson is a graduate of the Massachusetts Institute of Technology, class of 1907, in naval architecture and marine engineering. Upon graduation he was engaged in hull construction work at the Bath Iron Works for a short time, after which he returned to the Institute, where he held the position of instructor in naval architecture for the next two years. His subsequent experience includes two years in machine shop work at the plant of The William Cramp & Sons' Ship & Engine Building Company, four and one-half years with the Welin Marine Equipment Company (two of these being in the capacity of naval architect), four years with the Munson Steamship Line supervising the construction of new ships and the reconstruction, repair and maintenance of ships operated by that company. He was also employed for a short period assisting in an analysis of cost operation of ships for the Furness Withy Company.

Mr. Gamon graduated from the department of naval architecture at the University of Michigan in 1910. His experience includes five years at the experimental model basin, Washington, D. C., one year in the scientific department of The William Cramp & Sons' Ship & Engine Building Company, one year in the scientific department, Bureau of Construction and Repair, United States Navy Department, one year as designer for the Welin Marine Equipment Company and three years as plant manager of the Welin plant, American Balsa Company, New York.

J. D. TOMLINSON, formerly operating manager of the United American Lines, Inc., has been elected vice-president of the American-Hawaiian Steamship Company.

HENRY DEARBORN has been elected president of the American-Hawaiian Steamship Company, which position was formerly held by the late George S. Dearborn, one of the pioneers in American shipping.

ROBERT B. M. WILSON has been appointed sales engineer of the Conveyors Corporation of America in the Chicago district. Mr. Wilson has had a number of years' experience in railroad construction and maintenance.

ALBERT CHRISTEN has recently been appointed general superintendent of the Consolidated Shipbuilding Corporation, Morris Heights, N. Y., to succeed Joseph S. Potter, who has been promoted to the position of sales engineer.

W. A. HARRIMAN has been elected chairman of the boards of directors of the American-Hawaiian Steamship Company, the American Ship & Commerce Corporation and the American Ship & Commerce Navigation Corporation; he is also chairman of the executive boards of the United American Lines, Inc., and the Merchant Shipbuilding Corporation.

SIR JOHN LUSCOMBE has recently been appointed chairman of Lloyd's Register. Sir John is a well known underwriter at Lloyd's, and was elected as member of Lloyd's in the year 1870. He has held the chairmanship of Lloyd's for the years 1902, 1908, 1909, 1912 and 1914. He was deputy chairman and treasurer of Lloyd's Register of Shipping from July, 1904, to June, 1906, and from July, 1919, up to the present time.

DAVID SARNOFF, formerly commercial manager of the Radio Corporation of America, New York City, was appointed general manager of this company at the recent meeting of the board of directors. Mr. Sarnoff will supervise and control the operation of the corporation's plant and in general will have charge of the high and low power ship stations and the maintenance of radio service. He will also have charge of the corporation's trans-oceanic communication system and the handling of negotiations for the sale and rental of apparatus. Mr. Sarnoff was born in Russia in 1891, and came to the United States in 1900, where he was first employed as a wireless operator at the Marconi station, Siasconset, Mass. Later he became manager of the Marconi station at Sea Gate, N. Y. Mr. Sarnoff is vice-president and a director of the Pan-American Wireless Telegraph and Telephone Company and was secretary of the Institute of Radio Engineers from 1915 to 1917. He is the author of several important papers on radio work.

David Sarnoff

J. HERBERT SCRUTTON, a partner of the firm of master porters, stevedores, etc., Scrutton Sons & Company, who operated until last February a line of passenger and cargo vessels between London and Glasgow to the West Indies, has been appointed deputy chairman and treasurer of Lloyd's Register in place of Sir John Luscombe. Mr. Scrutton was chairman of the General Shipowners' Society for the years 1905 to 1906 when he first took his seat on the committee of Lloyd's Register and on which he has since served continuously.

Shipbuilding and General Marine News

Contracts for New Ships — Shipyard Improvements — Engineering Projects—Improved Appliances—Personal Items

Atlantic Coast Shipbuilders' Association Expands to Include Dry Dock and Repair Yards

Recognizes Claim That Equal in Importance to Building Ships Is Keeping Them in Repair — Annual Meeting Hears Interesting Reports and Elects Officers

Extending its field of usefulness to cover the entire shipbuilding industry, the Atlantic Coast Shipbuilders' Association, membership in which heretofore was confined to shipyards engaged in the construction of steel vessels, at its annual meeting in Philadelphia, Monday, May 9, adopted a recommendation made by Clarence Samuel King in his annual report as secretary that an effort be made through a membership committee to bring within the association every shipbuilding and repair plant on the Atlantic seaboard and Gulf of Mexico, with the view of establishing closer business relations, securing united and co-operative action on the fundamental problems of the industry, and standardizing as far as possible the conditions under which marine work is done.

This action recognizes the claim of dry dock and marine repair plants that equal in importance to building ships is keeping them in repair, and opens the way for an organization more or less national in scope which will continue along the conservative but constructive lines that made the Atlantic Coast Shipbuilders' Association a powerful and influential stabilizing force during the war and an even greater facteor in the transition from war to peace.

With a membership comprising substantially every recognized shipyard on the Atlantic and Gulf coasts engaged in building steel vessels, the association will now have the co-operation of many repair yards, of which there are approximately 140 in the east, in its determination to further the American merchant marine and establish shipbuilding as a permanent American industry.

The meeting brought to Philadelphia representatives of every shipbuilding district in the east, some of the shipyards sending delegations consisting of as many as seven members. The territory represented extends from Bath, Me., along the Atlantic Coast and Gulf of Mexico to New Orleans, La. Sessions were held morning, afternoon and evening, with the annual dinner at the Bellevue-Stratford Hotel as the outstanding entertainment feature.

While the executive officers of the various shipbuilding companies were discussing the merchant marine and the future of shipbuilding as a permanent American industry, experts to whom were assigned the more technical problems of ship construction held a conference on general shipbuilding problems. The labor situation came in for a large share of attention at the general conference, which was held throughout the afternoon in the association's large suite of offices on the second floor of the Estey building, and steps were taken to standardize wage rates, hours of labor and conditions of employment by making uniform as far as possible in each local shipbuilding district wage readjustments and construction cost liquidation now under way.

Many of the association's important activities were reviewed in the reports of the chairmen of the various committees under whose direction the special subjects were handled. H. Birchard Taylor, vice-president of the Wm. Cramp & Sons Ship and Engine Building Company, president of the association, and W. G. Coxe, vice-president and general manager of the Pusey & Jones Company, with shipyards at Gloucester, N. J., and Wilmington, Del., as chairman of the executive committee, discussed the work of the administrative council, in which is vested the government of the association and the administration of its business and affairs. They emphasized the readiness of the association to protect the interests of its members in conditions that continually arise in the shipbuilding industry, with its many policies to be formed, attesting to the splendid spirit of loyal co-operation in which the members have worked together, and pointing out the accomplishments of great mutual benefit that have come through these collective efforts.

R. H. M. Robinson, president of the Merchant Shipbuilding Corporation, reported that the general committee, of which he is chairman, expects during the coming year to initiate certain activities in connection with ship financing, which plans and other recommendations of policy will be announced as soon as the committee has had an opportunity to review and co-ordinate the work of the committees on contracts, classifications, cost accounting, labor board and marine and plant insurance.

The committee on marine and plant insurance, through its chairman, Frederick P. Palen, vice-president of the Newport News Shipbuilding and Dry Dock Company, reported that an investigation shows that builders' risk insurance, which is of first importance to shipbuilders, is very well standardized as to the policy forms, and the rates charged are so nearly uniform that the committee did not consider it necessary to recommend any changes from the present practice.

As a development of the association's policy to deal intelligently with and to improve the conditions of production and employment in the shipyards, the Atlantic Coast Shipbuilding Industrial Board, created by agreement between some members of the association and the Metal Trades Department of the American Federation of Labor, was described by its chairman, William T. Smith, vice-president of the Merchant Shipbuilding Corporation. According to Mr. Smith, the purpose of the board is to promote continuity of employment and uninterrupted production in the signatory shipyards, one clause of the agreement providing that no strike or cessation of work by employees or lockout by builders shall occur during the life of the agreement. The primary functions of the board are to interpret, determine and enforce the standards of wages, hours, classifications and working conditions in the signatory shipyards. This agreement was executed August 20, 1919, to endure for one year, and has since been continued without date, provision being made that any signatory can withdraw upon thirty days' notice.

Another important work which the association has undertaken and successfully consummated, according to George D. Martin, comptroller of the William Cramp & Sons Ship and Engine Building Company, is that of developing uniform methods of cost accounting for the shipyards.

The past year witnessed the first study given the subject of ship classification by the association members as an organization, this work being directed by W. A. Dobson, naval architect of the William Cramp & Sons Ship and Engine Building Company, who several months ago accepted the chairmanship of the committee on classification, and since then has been in close co-operation with the American Bureau of Shipping, which invited suggestions from the committee to improve the usefulness and efficiency of the Bureau. Mr. Dobson's report analyzed the classification work of the American Bureau of Shipping and gave a brief resumé of recommendations which the committee believes will be helpful to the Bureau and will increase its standing as a thoroughly efficient classification society.

Paul Gendell, employment manager of the New York Shipbuilding Corporation, reported as chairman of the employment managers' committee on the co-operation

that has prevailed among the heads of the shipyard employment departments.

The new Administrative Council organized immediately following the installation of its members and elected officers of the Association for the ensuing year as follows:

President.—James Lee Ackerson, vice-president Merchant Shipbuilding Corporation.
Vice-President.—George H. Bates.
Treasurer.—Sidney M. Henry.
Secretary.—Clarence Samuel King.

SHIP REPAIRED

One Hundred and Ninety Shell Plates Removed and Rerolled for Steamer "Nedmac"

The S. S. *Nedmac* went on the rocks some months ago off the British Isles. After undergoing emergency repairs in England the ship crossed the Atlantic, but on arrival in American waters was found to be in such a serious condition, owing to warping of the hull plates and resultant leaks, that it was immediately ordered into dry dock. Examination of the hull disclosed the necessity for removing and rerolling 190 shell plates.

New Hudson River Steamer

The new Hudson River Day Line steamer *De Witt Clinton* received her first grooming Thursday, May 12, in a trial spin up the Hudson. The steamer was built in 1913 for the Grand Trunk Railway, but was never put in commission until operated by the United States Navy, when she made an honorable war record for about seven months. She is 340 feet long, with extensive outside deck area, the work of transformation having recently been completed by the Todd Shipyards Corporation at the Tietjen & Lang yard.

In anticipation of the initial trip up the Hudson, a brass-bound cask containing some of the water of Lake Erie was brought from Buffalo in the care of George Clinton, an eminent lawyer of that city and a grandson of De Witt Clinton, for whom the steamer is named. When the party reached a point opposite the Hudson River Day Line pier, Mr. Clinton emptied the cask into the Hudson, thus repeating the ancient ceremony which was performed by his illustrious grandfather De Witt Clinton, at the opening of the Erie Canal in October, 1825.

Growing Trade for Vessels Arranged for Ventilation and Refrigeration

The Atlantic Gulf & Pacific Steamship Corporation reports that the *Henry S. Grove* is now bringing a shipment of 1,000 cases of fresh eggs, as a trial shipment, in addition to 50,000 boxes of citrus fruit and general cargo from the west coast. It will be remembered that the *Charles H. Cramp*, another vessel of their fleet, had the distinction of bringing the first shipment of fruit via the Panama Canal to Atlantic coast ports.

Lester Collins, refrigeration technologist for the Department of Agriculture, made the trip on the *Cramp* on her first voyage as a fruit carrier, and in company with A. H. Haag, marine superintendent of the line, thoroughly inspected the fruit upon its arrival in Philadelphia. It is most interesting to note that the total decay was less than 5 percent, and in many instances less than 1 percent, which is a far better result than can be obtained by rail shipments.

The importance of this trade to our merchant marine is emphasized by the fact that the Atlantic, Gulf & Pacific Steamship Corporation has not had one ship idle during the existing shipping slump.

Electric Drive Ship Eclipse Completes 26,500-Mile Voyage Showing Notable Performance

The S. S. *Eclipse*, of the United American Line, America's first electrically-propelled cargo carrier, docked at pier 21, Staten Island, on May 19, having completed her first ocean voyage with her new electric drive—a trip of 26,500 miles, without the slightest hitch to any of her machinery.

She was met at Quarantine by H. B. Taylor, chief turbine engineer of the United States Shipping Board, who congratulated the officers of the boat on the fine performance of her equipment and the complete success attending her initial trip.

The *Eclipse* left New York on November 12. Her first stop was Port Said. She then proceeded to Singapore and Java, took on a cargo and left Bombay on her return, March 23. Both going and coming she encountered heavy seas, but maintained a speed of better than 10 knots, covered the distance, it is claimed, in one week less time than required for similar boats not equipped with the electric drive and with a great saving in fuel used, as compared with trips taken by her before her propulsion machinery was changed from the geared turbine to the electric drive.

Capt. A. J. Shrader, of the *Eclipse*, declared as he left his cabin when the vessel docked that the trip had been the best in his experience, that not the slightest trouble had occurred in any part of the equipment.

"There is no comparison between the electric drive on this boat and the geared turbine or the reciprocating engine drive." He said, "I have had considerable experience with the geared turbine propulsion, and this beats it in every way. We made every port on schedule, maintained a speed of better than 10 knots for the entire trip, and I can say nothing but words of praise for the equipment."

His remarks were duplicated by Chief Engineer Carageorge and by others on the ship. From the quarantine engineer it was learned that the *Eclipse* had saved two months for the trip over vessels without the electric drive.

One passenger was brought back, Col. W. A. Castle, military attache to the American High Commission at Constantinople.

The *Eclipse* was built at the Bethlehem Shipbuilding Corporation's Union Iron Works, San Francisco, in 1918. Last summer her propulsion apparatus was changed by the Shipping Board to the turbine electric drive. Contrary to reports that special electrically trained men would be required to operate the vessel, the same crew which manned the *Eclipse* before the change was used, and not the slightest difficulty was experienced. Engineers operated the vessel as easily as a motorman does a trolley car, its simplicity being one of the marked features of the trip.

In addition to the many economical advantages of the electric drive over steam engine or other type propulsion, the *Eclipse* has been found much easier to control. The pilot, who has held such a berth for 35 years, declared that the *Eclipse* was under better control than any ship with a different type drive he had ever been on. Tests have shown that the propeller can be reversed from full speed ahead to full speed astern with ease in 10 seconds. Then, too, there was a uniformity of propeller speed, which prevented racing of the propeller in heavy seas, and the total lack of vibration.

The *Eclipse* is the first of twelve 12,000-ton vessels being equipped by the General Electric Company with the electric drive for the Shipping Board. Her electrical equipment consists of a steam turbine and a 2,300-volt generator, driving a 3,000-horsepower motor at 100 revolutions per minute.

SHIPOWNERS' PROBLEMS

Association Names Technical Committee for Representation

An important movement toward more comprehensive handling by American shipowners of problems relating to structural standards for American ships, especially with reference to bulkheads as well as to load-line regulations, general design and engining, has been instituted by the American Steamship Owners' Association, 11 Broadway, New York.

Feeling that the shipowners should have the best technical representation in national and international conferences dealing with these problems, and deliberations of every character relating to legislation and the adoption of official regulations intended to improve American merchant ships, the owners' association has appointed a special technical committee to represent it in such matters.

The members of the committee are as follows:

William Francis Gibbs, chief of construction, International Mercantile Marine Company, chairman.

Capt. O. W. Koester, vice-president in charge of construction, United States Mail Steamship Company.

John H. Telford, superintending engineer, Munson Steamship Line.

C. A. Ward, Jr., naval architect, Merchant Shipbuilding Corporation.

A. S. Hebble, superintending engineer, Southern Pacific Company.

James Donald, president, States Marine & Commercial Company, Inc.

Warren T. Berry, superintendent, marine construction, New England Steamship Company.

PORT IMPROVEMENTS

Large Sums to Be Expended for Development of Harbors

Approximately $1,750,000 worth of docks, wharves, warehouses and storage yards comprising several units of the final port development plans are about to get under way at Wilmington, Del. The plans, which comprise the last word in engineering achievement, call for the creation of a port along the banks of the Christiana, one mile from the Delaware river, into which the Christiana flows, that the Board of Harbor Commissioners of this city believe will eventually make this port one of the most prominent along the eastern coast, even though it is a matter of 60 miles inland from the Atlantic.

The initial project will consist of a quay wall approximately 1,200 feet in length, of skeleton concrete construction supported on timber piles. At the upstream end will be located a coastwise cargo shed for the accommodation of boats requiring side port loading. At the lower end will be a transit shed 400 feet long by 120 feet wide flanked by a wing shed 500 feet long by 120 feet wide for the temporary storage of cargo. Between these buildings and the coastwise cargo shed will be an open storage yard, where heavy machinery and other bulk cargo not affected by the weather may be stored. Back from the river front a car classification and temporary holding yard will be built. Minor buildings such as pump house, cafeteria and locomotive house are also included in the design. A water tower will be supplied. The development will be connected by a concrete roadway with Christiana avenue, which will link it up with the state highway system. It is expected that mechanical appliances will be used to a large extent in handling cargo, and to this end provision is being made for the installation of gantry cranes, both heavy and light tractors and trailers, industrial trucks. an escalator in the coastwise storage shed, and cargo masts along the face of the main transit shed.

NEW YORK

For dredging the main channel up to the head of Mill Basin to a depth of 18 feet, and necessary retaining walls along the bulkhead line so that the channel may be dredged along Flatbush avenue, Brooklyn, the New York Board of Estimate and Apportionment has authorized the issue of corporate stock to the amount not exceeding $750,000. The Board has also adopted a resolution authorizing the issue of serial bonds in the amount of $175,180, to be used by the Department of Plant and Structures for reconstruction work at municipal ferry terminals. The expenditures will be as follows: For reconstruction of racks and bridge at St. George, $68,160; at Whitehall street, $44,510; at South street, $13,770, and at 39th street, Brooklyn, $48,740.

NORFOLK

At Norfolk, Va., the city, through its port commission, which body was created by the Council, is contemplating the construction and erection of additional pier facilities, with a grain elevator adequate to meet the local needs.

Four Million Dollars to be Invested By New York City in Ferryboats and Equipment

Approximately four million dollars will be New York's latest investment in municipal ferryboats, terminals, equipment and operation, according to official information obtained by MARINE ENGINEERING. The projects now under consideration, and which are believed to be moving rapidly ahead, include the building or purchase of steamers, the construction of new and repair of old terminals and the reconditioning of boats now in use. Seven routes, including the Stapleton line, are in the present programme.

The services are as follows:

Classon Point to College Point, which it is hoped to start about July 1. A slip is to be built at Classon Point.

From East 23d street, Manhattan, to Greenpoint avenue, Brooklyn. This line is now under a private ownership, which has served notice of its intention to quit. Three boats may be purchased and about $30,000 spent on the terminals.

It is proposed to re-establish service between Broadway, Williamsburgh, and Grand street, Manhattan, which service was abandoned three years ago. The sum of $742,000 has been asked for this line, of which sum $480,000 will probably be spent for either the purchase of two boats or the building of two new ones. It is understood that these craft must be from 170 to 190 feet in length, in order to accommodate the traffic.

The Union Ferries, which Commissioner Whalen has recommended be taken over by the city and which run from Fulton street, Manhattan, to Fulton avenue, Brooklyn; Whitehall street, Manhattan, to Atlantic avenue, Brooklyn, and Whitehall street to Hamilton avenue, Brooklyn, the latter being considered of vital importance to the Red Hook section of Brooklyn.

For operation during the remainder of the year, $600,000 will be requested, although it is estimated that the operating receipts will reach a total of $750,000.

The lines enumerated are in addition to the new service to be established between lower Manhattan and Stapleton, S. I.

The Classon Point and Broadway-Grand street projects have been approved by the Sinking Fund Commission, it was stated. All are pending in the Board of Aldermen, and it was estimated that during the coming month most, if not all, of the projects will have reached the appropriation stage.

Commissioner Whalen, it is announced, has studied the disparity in cost of operation between municipal and private ownership, and has laid out a system of operation incorporating radical economies, which he believes will enable the city to operate these ferries at a very small increase in cost as compared with past experience with private operation.

America to Build 20,000-Ton Electrically Propelled Fuel Ship for the Japanese Navy

Japan is to be the second nation to use the electric drive in its navy, a contract having just been closed with the New York Shipbuilding Company, of Camden, N. J., for a 20,000-ton fuel ship, similar in size to the U. S. S. *Jupiter*, recently named the *Langley*. The design of the vessel calls for a waterline length of 496 feet, with a beam of 67 feet.

Interested in the success of the electric drive, proven by the ten years' service of the *Jupiter* and the two years or more of practical service of the U. S. S. *New Mexico*, the world's first electrically-propelled battleship, Japan has decided to follow America's steps in first electrifying a smaller navy ship. There is no doubt that if this vessel operates successfully future large ships of the Japanese Navy will be electrically propelled.

It was through the untiring efforts of Captain M. Yokura that the Japanese Government decided to introduce the electric drive in its navy. Economy in fuel is of paramount importance, and Captain Yokura therefore decided to install electrically-driven auxiliaries throughout, as well as to equip the boilers with superheaters so as to obtain about 200 degrees F. of superheat. This last mentioned improvement will mean a fuel saving of at least 10 percent.

The G-E equipment, purchased from the International General Electric Company, will consist of an 8,000-horsepower turbine generator supplying power to two 4,000-horsepower 120 revolutions per minute, synchronous motors; also two 500-kilowatt direct-current turbo sets, one of which is to be sufficiently large to furnish the exciting current for the main generating units, as well as power to drive all the auxiliaries, such as the blower motor, steering gear, the gypsy, radio apparatus, refrigerating plant, laundry and lighting equipment.

There is also furnished a 650-kilowatt alternator, which can be connected by means of a coupling to either of the 500-kilowatt, direct-current auxiliary turbines, so that in case of failure of the main driving unit, or any of its auxiliaries, this small generator will give sufficient power to propel the vessel at about 7½ knots.

This Japanese fuel ship will be completed in twelve months' time, and is expected on her trials to make a record in fuel economy because of her watertube boilers of 270 pounds gage steam pressure with 200 degrees F. of superheat, and the fact that synchronous motors are to be used for the main drive and that all auxiliaries are to be electrically operated. The vessel will have Isherwood longitudinal framing.

Marine Construction News of the Month

Ship Contracts—New Ship Concerns and Shipyard Improvements—Terminal Projects—Government Contracts

SHIPS AND SHIPBUILDING

Light Vessel Repair.—Repairs and docking of light vessel No. 49 has been awarded by the Bureau of Lighthouses to the Spedden Shipbuilding Company, Baltimore, Md.

To Build Three Lighters.—The Dravo Construction Company of Pittsburgh, Pa., were low bidders for three 60 foot steel lighters for the Shipping Board, the price being $10,500 each.

Repairing Steamer, Brooklyn, N. Y.—On a bid of $8,750, the Morse Dry Dock & Repair Company was awarded the contract to repair the steamer Honnedaga, a Shipping Board vessel.

Drydock.—The Jahncke Dry Dock company is building an 8,000 ton steel drydock, and is reported to have purchased the plant of the Crescent City Machine & Manufacturing Company.

Tankers, for English Interests—Recent reports from London state that the Eagle Oil Transport Company, Ltd., expects to lay down four more 11,000-ton tankers in an American shipyard.

Shipyard Sold.—It is reported that Irving W. Reed has purchased the shipbuilding plant which he had sold to the East Coast Ship Company, and will soon start building small boats as he did in past years.

To Rebuild Yard.—The National Shipbuilding Company, Goderich, Ont., will rebuild and install new equipment at its plant which was recently destroyed by fire. The entire cost will amount to about $100,000.

Radio Installations on New Vessels—A contract for installing two kilowatt 500 cycle radio sets on four new tankers under construction for the Standard Oil Company has been awarded to the Radio Corporation of America.

To Refit and Overhaul Schooner, Philadelphia, Pa.—The American schooner Hortense has been sold by the United States marshal at Pensacola, Fla., to O'Hara Bros. & Company, of Philadelphia, Pa., for $6,200. The vessel will be refitted and overhauled.

New Fireboat, Norfolk, Va.—Latest and official advices from the city of Norfolk, Va., are to the effect that the city is about to purchase a new fireboat and is making a study of the comparative merits of a steam propelled craft against a gasoline propelled craft.

To Overhaul Vessel, San Francisco, Cal.—The steamer Admiral Farragut, of the Admiral Line, has completed her last run on her South American schedule, and will be laid up temporarily for fumigation and a general overhauling. The number of her cabins will also be increased by five.

Barges, Pensacola, Fla.—The Pensacola Shipbuilding Company has contracted to build for the Alexandria Coaling Company, New Orleans, La., two 600-ton coal barges, 135 feet in length and 30 feet beam. It is reported that four smaller steel oil barges will also be built for a Tampico oil company.

To Repair Vessel, Brooklyn, N. Y.—The contract for repairs to the Shipping Board steamer Porto Rico has been awarded to the Robins Dry Dock & Repair Company, Brooklyn, N. Y., on their bid of $9,300. The work includes among other things the installation of six new furnaces of the Morison type.

To Ask for New Pump Bids, New York—It was learned to-day that bids submitted on April 4 for the installation of turbine fire pumps on the New York fireboats James Duane and Thomas Willard have been filed, and new tenders may be asked for later. The previous bids ranged from $30,000 to $48,000.

Zulia Contract Awarded, Chester, Pa.—The contract for reconditioning the Red "D" steamer Zulia has been awarded to the Sun Shipbuilding Company. It is understood that the work contemplates the installation of an oil-burning system, and will involve the expenditure of approximately $100,000.

Victorious Contract Awarded.—Announcement is made of the awarding of the contract for installing electric drive in the steamship Victorious, of the Shipping Board to the Tebo Yacht & Basin Company, Brooklyn, N. Y. It is stated that the cost will be $95,530, which includes voyage repairs and betterments.

Six Dumpers Contemplated—According to information obtained by MARINE ENGINEERING, construction of six sea dumpers is contemplated by the Street Cleaning Department of the city of New York No definite date for issuing the plans and specifications has been given. It is believed that these boats will cost close to $200,000.

May Convert Ten Ships.—Decision to convert ten 3,800 ton steel cargo carriers into refrigerator vessels for the purpose of operating them on the intercoastal service under an arrangement with the California Fruit Grocers' Exchange is accredited to the American Shipbuilding Company. An agreement with the Fruit Growers' Exchange is reported to have been reached recently at Los Angeles.

To Recondition Steamers, Brooklyn, N. Y.—Following the awarding of the contract for installation of third class passenger accommodations in the Shipping Board steamer Centennial State to the Robins Dry Dock & Repair Company at a price of $128,000, it was announced that three additional "State" ships will follow the Centennial State for similar reconditioning.

Completing Plans—Latest authoritative information is to the effect that a force of men is now engaged in completing plans and specifications for the reconditioning of the Agamemnon and Mount Vernon, and the opinion was expressed that the work would be put out for competitive bidding after the vessels have been turned over to the steamship line by the Shipping Board.

Overhauling Vessels, Hoboken, N. J.—The steamships Bristol and Fairmont of the United American Line went to the yards of the W. & A. Fletcher Company for dry docking, a general overhauling, and machine and tank equipment work. The Shipping Board steamer Collingsworth is also at this yard for renewal of bow plates, hawse pipes, repairs to stem, machinery, decks, hull and top sides.

Moore Yards Busy, Oakand, Cal.—Work is being rushed on the freighter Ohioan of the Williams-Diamond Line, which is now in drydock at the Moore Shipbuilding Yard. The vessel is having new blades attached to her propeller and her tail shaft is being drawn. The Shipping Board freighter West Keene is being overhauled and repairs are also being made on the Alaska Packer's ship Star of Russia.

Repairing Steamer, Hoboken, N. J.—A contract for repairs to the Shipping Board steamer Eastern Moon was awarded by the Shipping Board to the W. & A. Fletcher Company on their bid of $17,050. Other bids were: Robins Dry Dock & Repair Company, $17,850; Morse Dry Dock & Repair Company, $23,900; Baltimore Dry Dock & Shipbuilding Company, $24,105; James Shewan Son, $25,994. The work includes the renewal of the ship's stern frame.

Suction Dredges, New York—Designs for two 15-inch suction dredges to be built in this country and shipped in knock-down sections to India are in the hands of N. E. McClelland & Company, Ltd., naval architects, 2 Stone street. The order for these craft was received through the engineering concern's Canadian office. Plans and specifications will not be completed for about six weeks although it is understood that the dredges will cost in the neighborhood of $175,000 each.

Tug, Dredge, Scows, Detroit, Mich.—The Department of Parks and Boulevards, Marquette Building, has let contracts for furnishing combination 16-inch hydraulic and 2½ yard dipper dredge to W. Logan, Jr., Waterford, N. Y., at a cost of $42,000; three scows, 12 by 34 by 125 feet to the Canal Construction Company, North American Building, Philadelphia, Pa., to cost $50,000; and contract for a steel tug and wooden scow No. 9 to E. Gray, Gray Haven street, $25,000.

To Convert Turbines—Announcement is made of the awarding of the contract by the Shipping Board to the General Electric Company for the modification of ten 2,500-horsepower marine turbines that were built for 200 pounds pressure, 50 degrees of superheat, for 200 pounds pressure and 250 degrees superheat, which is expected to cut the fuel consumption about 20 percent. This does not include the steamship Volunteer, which makes a total of eleven turbines to be converted.

To Recondition Liners—The placing of contracts which will call for the expenditure of over two million dollars, involving the reconditioning of the steamships Agamemnon and Mount Vernon, by the United States Mail Steamship Company, is being awaited with considerable interest in ship repair circles in New York and vicinity. Although definite dates are not available at this time, it is believed that the work to be done on these two ships will be ready for bids in the near future.

Dredger, Antwerp, Belgium—The port authorities are asking for tenders for the supply to the port of one dredger, which will be capable of dredging to a depth of 15 meters (about 49 feet) beneath the water level. The dredger must be provided with a main engine of the horizontal or vertical type, compound, with two cylinders, working with steam saturated at 10 atmospheres. The boiler should have two Morison furnaces. Seven steam windlasses are also to be supplied. The buckets should have a capacity of a least 600 liters (about 160 gallons). Further particulars can be obtained from the secretary of the Antwerp Town Hall.

Ferryboats, Boston, Mass.—The City of Boston is expending at the present time, under contracts made last year, approximately $1,165,000 for the improvement of the ferry service. This work includes two new steel ferryboats of the 4-roadway type and one reconstructed ferryboat to provide for four teaming roadways; also certain changes in the entrances and exits which will allow two lines of traffic to and from the boats in place of the 1-line entrances and exits. One of the new boats is being built by the Groton Iron Works, Groton, Conn., at a cost of $379,950, and the other by the Winnisimmet Ship Yard, Inc., Chelsea, Mass., at a cost of $335,000, and the rebuilding of the other boat is being done by the Richard T. Green Company, Chelsea, Mass., at a cost of $165,000.

Pier, Portland, Me.—According to Henry F. Merrill, chairman of the port directors of Maine, actual construction will soon be commenced on a large new pier for which the state has appropriated $1,500,000. The pier will be 1,000 feet long and 360 feet wide, with a depth of water alongside of 35 feet. It will be equipped with the most modern freight-handling machinery, and rates will be reasonable so as to attract business. It is expected that the pier will be completed in about a year.

To Change Vessel, Baltimore, Md.—Changes to be made in the steamer Hawkeye State will involve a general breakout of parts of the ship to make her accommodate different classes of passengers for which her trade on the Pacific makes a demand. There will be three bidders for the work, the Baltimore Dry Docks & Shipbuilding Company, Bethlehem Shipbuilding Corporation and the Newport News Shipbuilding Company. The work will probably require a month to complete. The vessel is now lying at Baltimore.

Steel Motorships Planned, New York—Preliminary plans for the construction of two 1,000 deadweight ton motorships are being prepared by Messrs. Seabury & de Zefra, Inc., 150 Nassau street, New York City, who have been commissioned by clients to provide for vessels up-to-date in every way. These ships will be of steel construction, operated by full Diesel engines, and all auxiliaries will be electrically operated. There will be accommodations for twenty-five first class passengers, and the ships will be equipped to attain a speed of 12 knots.

Repair Contracts Awarded.—The contract for repairing the steamer Persian of the Merchants & Miners' Transportation Company which was recently damaged by fire in Baltimore harbor was awarded to the Baltimore Dry Docks & Shipbuilding Company on a bid of $17,249 and 23 days to complete the work. Other bids for the job were as follows: Globe Shipbuilding & Dry Dock Company, $18,500 and 24 days; Newport News Shipbuilding Company, $22,580 and 18 days; Old Dominion Company of Norfolk, $51,506 and 90 days. Several other small repair contracts also awarded at Baltimore include the Shipping Board steamer Wahan, awarded to the Union Shipbuilding Company on its bid of $609; the steamer Westwood awarded to the Obrecht Company at $1,670; the Carenco to the Baltimore Dry Docks & Shipbuilding Company at $2,426, which was also awarded the Robin Adair, a Pacific Coast vessel.

Activities at San Pedro, Cal.—A contract for repairs to the steamer Edward Luckenbach, which recently went aground, has been awarded to the Los Angeles Shipbuilding & Dry Dock Company, the cost to total close to $60,000. The work will occupy three weeks' time, and will include bottom repairs, renewing one boiler head, four furnaces, and one main boiler, installing locomotive superheaters in three main boilers, installing an entire new gravity lubricating system for main turbine reduction gears, removing old and installing new reduction gears and pinions and making miscellaneous repairs to shaft pinions, etc. Other vessels to be repaired so far this month at this yard include the steam schooner Carlos, yacht Northtown, the destroyers 302 and 303, the steam schooner Stanwood; following which, it is understood, the steamers Cabrillo and Hermosa, two units of the Wrigley fleet in the Catalina Island service, and two additional destroyers will be docked for repairs.

SHIPS UNDER CONSTRUCTION IN VARIOUS YARDS FOR UNITED STATES NAVY

Vessels under construction for the United States Navy, their degree of completion and the probable dates of completion as reported April 30, 1921, are announced by the Bureau of Construction and Repair, Washington, D. C., as follows:

Type Number and Name	Contractor	Per Cent. of Completion May 1 Total
BATTLESHIPS (BB)		
44 *California*	Mare Island Navy Yard	96.5
45 *Colorado*	New York S. B. Corpn.	71.3
46 *Maryland*	Newport News S. B. & D. D. Co.	98.3
47 *Washington*	New York S. B. Corpn.	63.1
48 *West Virginia*	Newport News S. B. & D. D. Co.	52.1
49 *South Dakota*	New York Navy Yard	29.1
50 *Indiana*	New York Navy Yard	25.8
51 *Montana*	Mare Island Navy Yard	22.1
52 *North Carolina*	Norfolk Navy Yard	29.4
53 *Iowa*	Newport News S. B. & D. D. Co.	19.3
*54 *Massachusetts*	Beth. S. B. Corpn. (Fore River)	3.
BATTLE CRUISERS (CC)		
1 *Lexington*	Beth. S. B. Corpn. (Fore River)	16.6
2 *Constellation*	Newport News S. B. & D. D. Co.	9.3
3 *Saratoga*	New York S. B. Corpn.	20.4
4 *Ranger*	Newport News S. B. & D. D. Co.	1.6
5 *Constitution*	Philadelphia Navy Yard	6.
6 *United States*	Philadelphia Navy Yard	6.
SCOUT CRUISERS (LIGHT CRUISERS CL)		
4 *Omaha*	Todd D. D. & Const. Corpn.	91.4
5 *Milwaukee*	Todd D. D. & Const. Corpn.	88.3
6 *Cincinnati*	Todd D. D. & Const. Corpn.	80.6
7 *Raleigh*	Beth. S. B. Corpn. (Fore River)	53.8
8 *Detroit*	Beth. S. B. Corpn. (Fore River)	53.6
9 *Richmond*	Wm. Cramp & Sons Co.	64.
10 *Concord*	Wm. Cramp & Sons Co.	62.
11 *Trenton*	Wm. Cramp & Sons Co.	44.
12 *Marblehead*	Wm. Cramp & Sons Co.	42.
13 *Memphis*	Wm. Cramp & Sons Co.	35.
Battleship No. 54—Keel laid 4-4-21.		
AUXILIARIES		
Fuel Ship No.1 8, *Pecos* (Oiler AO6)	Boston Navy Yard	82.5
Amm. Ship No. 2, *Nitro* (AE2)	Puget Sound Navy Yard	Comm.
Repair Ship No. 1, *Medusa* (AR1)	Puget Sound Navy Yard	60.6
Dest. Tender No. 3, *Dobbin* (AD3)	Philadelphia Navy Yard	57.3
Dest. Tender No. 4, *Whitney* (AD4)	Boston Navy Yard	21.
Sub. Tender No. 3, *Holland* (AS3)	Puget Sound Navy Yard	16.8
Aircraft Tender, *Wright* (AZ1)	Tietjen & Lang	70.
PATROL VESSELS		
Gunboat No. 22, *Tulsa* (PG22)	Charleston Navy Yard	64.6
Authorized but not under construction or contract.		
(1) Transport No. 2		
DESTROYERS		
135 *Tillman*	Charleston Navy Yard	Comm.
230 *Paul Jones*	Wm. Cramp & Sons Co.	Del.
250 *Lawrence*	New York S. B. Corpn.	Del.
327 *Preston*	Beth. S. B. Corpn. (San Fran.)	Del.
328 *Lamson*	Beth. S. B. Corpn. (San Fran.)	Del.
330 *Hull*	Beth. S. B. Corpn. (San Fran.)	Del.
331 *Mac Donough*	Beth. S. B. Corpn. (San Fran.)	Del.
332 *Farenholt*	Beth. S. B. Corpn. (San Fran.)	90.7
333 *Sumner*	Beth. S. B. Corpn. (San Fran.)	87.3
334 *Corry*	Beth. S. B. Corpn. (San Fran.)	81.
335 *Melvin*	Beth. S. B. Corpn. (San Fran.)	77.8
338 *Wasmuth*	Mare Island Navy Yard	97.5
339 *Trever*	Mart Island Navy Yard	94.6
340 *Perry*	Mare Island Navy Yard	59.5
341 *Decatur*	Mare Island Navy Yard	55.6
Destroyers authorized but not under construction or contract.		
(12) Nos. 348 to 359 inclusive.		
SUBMARINES		
115 *S-10*	Portsmouth, N. H., Navy Yard	90.6
116 *S-11*	Portsmouth, N. H., Navy Yard	86.2
117 *S-12*	Portsmouth, N. H., Navy Yard	76.2
118 *S-13*	Portsmouth, N. H., Navy Yard	72.3
123 *S-18*	Electric Boat Co. (Quincy)	97.
124 *S-19*	Electric Boat Co. (Quincy)	96.5
125 *S-20*	Electric Boat Co. (Quincy)	98.5
126 *S-21*	Electric Boat Co. (Quincy)	94.9
127 *S-22*	Electric Boat Co. (Quincy)	95.8
128 *S-23*	Electric Boat Co. (Quincy)	94.
129 *S-24*	Electric Boat Co. (Quincy)	93.
130 *S-25*	Electric Boat Co. (Quincy)	93.5
131 *S-26*	Electric Boat Co. (Quincy)	92.4
132 *S-27*	Electric Boat Co. (Quincy)	91.
133 *S-28*	Electric Boat Co. (Quincy)	91.6
134 *S-29*	Electric Boat Co. (Quincy)	90.5
136 *S-31*	Electric Boat Co. (Quincy)	97.5
137 *S-32*	Electric Boat Co. (Quincy)	94.4
138 *S-33*	Electric Boat Co. (Quincy)	99.2
139 *S-34*	Electric Boat Co. (Quincy)	94.5
140 *S-35*	Electric Boat Co. (Quincy)	89.6
141 *S-36*	Electric Boat Co. (Quincy)	86.
142 *S-37*	Electric Boat Co. (Quincy)	82.4
143 *S-38*	Electric Boat Co. (Quincy)	72.2
144 *S-39*	Electric Boat Co. (Quincy)	70.5
145 *S-40*	Electric Boat Co. (Quincy)	71.6
146 *S-41*	Electric Boat Co. (Quincy)	73.4
153 *S-42*	Electric Boat Co. (Quincy)	60.4
154 *S-43*	Electric Boat Co. (Quincy)	60.6
155 *S-44*	Electric Boat Co. (Quincy)	58.8
156 *S-45*	Electric Boat Co. (Quincy)	59.9
157 *S-46*	Electric Boat Co. (Quincy)	58.2
158 *S-47*	Electric Boat Co. (Quincy)	58.
159 *S-48*	Lake T. B. Co. (Bridgeport)	90.
160 *S-49*	Lake T. B. Co. (Bridgeport)	83.2
161 *S-50*	Lake T. B. Co. (Bridgeport)	73.5
162 *S-51*	Lake T. B. Co. (Bridgeport)	66.5
FLEET SUBMARINES		
60 *T-2* (SF 2)	Electric Boat Co. (Quincy)	98.7
163 *V-1* (SF 4)	Portsmouth, N. H., Navy Yard	
164 *V-2* (SF 5)	Portsmouth, N. H., Navy Yard	
165 *V-3* (SF 6)	Portsmouth, N. H., Navy Yard	

*Correction of error in report of April 10, 1921.

Note: Submarines authorized but not under construction or contract.

Fleet Submarines (6) Nos. 166 to 171.

Neff Submarine (1) No. 108.

SHIPYARDS AND DRYDOCKS

Marine Railway, Sydney, N. S.—The Sydney Foundry & Machine Works is reported to have started the construction of a new marine railway, which is expected to be completed and ready for the accommodation of ships during July.

Shipyard Addition, Petersburg, Fla.—The Marine Ways Machine Company, Seventh street, has plans under way for the construction of a one-story building, 50 by 150 feet, to cost $50,000, and into which new equipment will be installed, including grinders, pipe threader, lathe, etc.

Marine Railway, New London, Conn.—The Thames Tow Boat Company has commenced the construction of a third marine railway of 1,500 tons deadweight capacity, to be completed next October. The company has contracts for repair work on a number of United States submarines and Eagle boats.

To Establish Shipyard, North Vancouver, B. C.—The Queensboro Shipyards, New Westminster, B. C., are reported to be negotiating for the lease of two waterfront lots at North Vancouver, with the option of purchase, for the establishment of a shipbuilding yard there. Joseph Crane is manager.

Plant Addition, Philadelphia, Pa.—It is reported that the William Cramp & Sons Ship & Engine Building Company, Richmond and Norris streets, has acquired property at Fletcher and Richmond streets at a price of $105,000, to be used in connection with its plant. The land measures 124 by 375 feet.

To Enlarge Plant, Build Wharf, New Orleans, La.—The Jahncke Dry Dock & Ship Repair Company will spend about $2,000,000 for new equipment and extensions to its plant and will also build a new 600 foot steel wharf below their present yard, which will give them much needed additional steamer repair berths. The Dock Board of New Orleans recently granted the company the right to use the additional 600 feet on the riverfront.

PORT IMPROVEMENTS

Bulkheads, Eustis, Fla.—Bids are being readvertised for the construction of bulkheads. Pere Prioleau is city engineer.

Dock, Sarnia, Ont.—The Imperial Oil Company plans to build a dock on Confederation street to cost about $125,000 from private plans.

River Terminals, Memphis, Tenn.—City has voted bonds amounting to $500,000 for the extension of river terminals. W. B. Fowler is city engineer.

Wharf, Marion, Mass.—The town plans to build a concrete wharf on Sippican Harbor to cost about $25,000. The engineer has not as yet been selected.

Channel, Tampa, Fla.—The sum of $67,000 is available for the completion of a deep waterway channel between Tampa and Sarasota, Fla. Address the Mayor of Tampa.

Pier, Gulfport, Fla.—Bonds, amounting to $13,000, have been issued for public improvements, including pier construction, yacht basin, lighting system, etc. S. J. Webb is town clerk.

Concrete Dock, Dubuque, Ia.—Plans are being prepared by the United States Engineer's Office for a new steel and concrete wharf 300 feet long and estimated to cost about $100,000.

Docks, Miami, Fla.—Plans for trebling the capacity of the municipal docks and to erect an additional 1,000-foot pier, costing $400,000, are contemplated by the city. Address the city engineer.

Dredging, Clinton, Ia.—The Clinton Company is having plans prepared for dredging the Elk River 1½ miles, involving the expenditure of

about $25,000. B. Anderson, Western building, is engineer.

Wharf, St. Rose, La.—The Petroleum Import & Export Company, a subsidiary of the Carson Petroleum Company, has let a contract to N. G. Scott, Hennen building, New Orleans, for the construction of a 500 by 30-foot wharf.

Dredging, Gray's Harbor, Wash.—Actual dredging work has been started at Cow Point, the scene of the most extensive operations of the port development programme, and it is expected will take the greater part of the year.

Coal Terminal, Cordova, Ala.—Material for the coal terminal to be built at Cordova, the head of navigation on the Warrior River, has been contracted for and is being delivered. All necessary facilities of the most modern type will be installed.

Breakwater, Corpus Christi, Tex.—The citizens of Corpus Christi have voted in favor of an appropriation of $100,000 for the construction of a breakwater in connection with the establishment of a port at this point of the coast.

Wharf, Lahaina, Maui—Preparations are under way for the construction of a large wharf according to Honolulu reports. More than half of the concrete piling for the new landing has already been constructed, the date for the completion of the work being set for 1922.

Conveying Machinery, Jacksonville, Fla.—The City Dock Commission is planning for the installation of loading and conveying machinery on the municipal docks. This work, in connection with other improvements and extensions to the docks, will cost about $1,000,000. John S. Bond is chairman.

Bulkhead, Dredging, Newark, N. J.—The city let contract for dredging Newark Bay from Port Newark to Kill van Kull, and building a bulkhead around the waterfront property south of the channel at Port Newark, to the Atlantic, Gulf & Pacific Company, 15 Whitehall street, New York, on a bid of $739,082.

Wharves, Etc., Shiner, Tex.—It is reported that the Shiner Compress Company, of which V. J. Grunder is president, will soon erect wharves, 120 feet by 500 feet, and sheds of mill construction, to be built under their own supervision. Two tubular boilers, each 72 inches by 18 feet, will also be installed.

Terminals, Nashville, Tenn.—A. J. Dyer, chairman of the Board of Transportation, let a contract to Foster & Creighton to construct the concrete river and rail terminals, including a warehouse. The project involves the expenditure of $300,000. Freeland Roberts, Independent Life Building, is engineer.

Ship Terminal Bids, Edgewater, N. J.—According to latest reports the Luckenbach Steamship Company, 44 Whitehall street, New York, will soon call for bids for the erection of the first unit of its proposed new ship terminal at Bull's Ferry. Hoisting and conveying machinery and other freight handling equipment will be installed.

Ferry Terminal Power Plant, St. George, S. I.—The Department of Plant and Structures, Municipal Building, New York, has preliminary plans under way for the proposed municipal electric light and power plant at the ferry terminals, St. George, S. I., which is estimated to cost $1,258,000. Grover A. Whalen is commissioner.

Municipal Piers, Baltimore Md.—The Port Development Commission purchased a tract adjoining the city's McComas street development, the site having 429 feet of water frontage, 1,400 feet deep, and contemplates the construction of groups of municipal piers. H. G. Perring is chief engineer,, and Bancroft Hill, harbor engineer.

Wharf, New Orleans, La.—According to W. O. Hudson, president of the Board of Port Commissioners, plans for the construction by the board of a $400,000 wharf behind which a warehouse will be built by the Mississippi-Warrior Barge Line are now under way. The proposed wharf will be approximately 600 feet in length and 75 feet wide.

To Deepen Harbor, Nassau—The Bahamas Legislature has authorized the development of the harbor of Nassau, a project which was considered at various times during the past half century, at an estimated cost of $1,250,000, half of which will be raised by a loan. The harbor is to be deepened to 35 feet over the bar at the entrance, and channel will be made 300 feet wide and 35 feet to the inner harbor, where a basin 35 feet deep will be provided.

Ocean Terminal, Seattle, Wash.—According to an application made by the Oregon Washington Holding Corporation, which is an affiliated interest of the Oregon Washington Railway & Navigation Company, to the United States Engineers branch of the War Department, Seattle, Wash., it is probable that the Duwamish Waterway may soon have a new water terminal 1,000 feet long by 80 feet wide, with two warehouses 150 by 450 feet in connection. It is proposed to build an ocean terminal having a frontage of 1,000 feet on the waterway and permission is sought to dredge the channel to a depth of thirty feet at low tide.

Pier Equipment, Staten Island, N. Y.—Electric traveling cranes, hoisting, and conveying machinery will soon be installed on the new piers now being erected by the Department of Docks, New York, between Tompkinsville and Clifton, S. I., and involving the expenditure of about $20,000,000. The piers are expected to be available for use in the fall and several companies have already leased the piers, including the Oriental Navigation Company, 39 Broadway, pier 3; Pennsylvania Railroad Company, Penn. Station, Pier 5; American Dock Company, pier 6; Wessel, Duval & Company, 25 Broad street, New York, pier 8; Moore & McCormack, 5 Broadway, pier 9; Edward M. Raphel & Company, 17 Battery place, pier 10; International Mercantile Marine Company, 9 Broadway, New York, pier 11; Pan American Terminal & Dock Company, 233 Broadway, New York, piers 12 and 13; Nippon Yusen Kaisha, 120 Broadway, pier 17; and the Pouch Terminal, Inc., 17 State street, pier 18.

GOVERNMENT WORK

Air Compressor, Charleston, S. C.—The Bureau of Yards and Docks, Navy Department, Washington, D. C., plans the installation of an air compressor.

Tower, Peking, China—Specification 4436, the Bureau of Yards and Docks, Navy Department, Washington, D. C., plans to erect and paint one 300-foot steel tower.

Electric Light and Power System, Quantico, Va.—The Bureau of Yards and Docks, Navy Department, Washington, D. C., plans to install an electric light and power system.

Dredging, Mich.—The United States Engineer Office, War Department, Washington, D. C., has rejected bids for dredging Princess Point cutoff at Keweenaw Waterway Channel.

Electric Distributing System, Charleston, W. Va.—Specification 4418, the Bureau of Yards and Docks, Navy Department, Washington, D. C., plans to install an electric distributing system.

Foundations for Machine Shop, Pearl Harbor, T. H.—Specification 4396, the Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until June 29 for constructing foundations for a machine shop.

River Improvement, Mich.—The Federal Government will spend $518,000 on improvements in the Detroit River during the coming year, according to an announcement credited to Major-General Beach, chief of the Government engineers.

Portable Water Supply, Lakehurst, N. J.—Specification 4424, the Bureau of Yards and Docks, Navy Department, Washington, D. C., plans to install a portable water supply system.

Radio Station, Annapolis, Md.—Specification 4419, the Bureau of Yards and Docks, Navy Department, Washington, D. C., plans to construct a high-power radio station and painting building.

Terminals.—The Government has leased a site from the city of St. Louis, Mo., upon which it will construct Federal docks, rail and river terminals, involving the expenditure of $250,000. Address Mr. Kiel, the mayor.

Dredging.—The United States Engineer Office, Room 710, Army Building, 39 Whitehall street, New York, will receive bids until 12 noon, June 23, 1921, for dredging and rock removal in the East River, New York. Further information may be obtained upon application.

Dredging Plant.—The United States Engineer Office, Jacksonville, Fla., will receive bids until June 10 to hire a dredging plant and crew for dredging and rock removal in the St. Johns River, Fla. Further information may be obtained on application.

Furnaces for Lighthouse Tender.—The Superintendent of Lighthouses, Boston, Mass., will receive bids until 2 P. M., June 6, 1921, for furnishing two furnaces for the tender Anemone. Further information may be obtained upon application.

Dump Scows, New York—The United States Engineer Office, Room 710, Army Building, 39 Whitehall street, New York, has let contract for furnishing and delivering three wooden hopper dump scows to the American Car & Foundry Company, 165 Broadway, at a cost of $194,862.

Dredging.—The United States Engineer Office, Jacksonville, Fla., will receive bids until June 10 for dredging and rock removal in the St. Johns River, Fla., to complete the work remaining in Arlington Cut from the unfinished contract. Further information may be obtained upon application.

Repair Steamer.—The Shipping Board has awarded to the Bethlehem Shipbuilding Company, Sparrows Point, Md., the contract to repair the steamer Conehatta on a bid of $2,530. The Baltimore Dry Docks & Shipbuilding Company bid $2,722, and the Globe Shipbuilding & Dry Dock Company $2,677.

Embankment, Dredging, Etc., Petersburg, Va.—The United States Engineer Office, Custom House, Norfolk, Va., will receive sealed bids until 12 o'clock noon, June 6, 1921, for constructing an embankment, earth fill, and dredging in the Appomattox River. Further information may be obtained on application.

Harbor Development.—Specification 4439, the Bureau of Yards and Docks, Navy Department, Washington, D. C., has let contract to the Great Lakes Dredging Company, 104 South Michigan avenue, Chicago, Ill., to construct a harbor at Great Lakes, Ill., at a price of $967,326. This work will occupy 500 days for completion.

Pier Contract Awarded, Charleston, S. C.—The Bureau of Yards and Docks, Navy Department, Washington, D. C., let contract to the Raymond Concrete Pile Company, 140 Cedar street, New York, at a price of $191,600, to construct an extension to the concrete pier No. 314 at the Navy Yard. The pier will be extended from a length of 520 feet to 875 feet.

To Sell Lighter.—Sealed proposals will be received until 10 A. M., June 7, at the office of Lieut.-Colonel O. S. Eskridge, Infantry, Room 318, Pier 2, Hoboken, N. J., for the purchase of the steam lighter Amackassin. Each proposal submitted should be accompanied by a certified check of 10 percent of the amount of bid, checks to be made payable to the Finance Officer, Army Supply Base, Brooklyn, N. Y.

Twenty Ships to be Constructed—New ships to be built for the United States Navy include twelve destroyers, one transport, six fleet submarines and one Neff submarine, according to official figures given out by the Bureau of Construction and Repair, Washington, D. C. It is stated that these ships have been authorized but are not yet under construction or contract. The keel for battleship No. 54 was laid by the Bethlehem Shipbuilding Corporation on April 4, 1921, with probable date of delivery in 1923.

Light Vessels.—Sealed proposals will be received at the office of the Commissioner of Lighthouses, Washington, D. C., until 2 P. M., June 21, 1921, and at the office of the Superintendent

of Lighthouses, Custom House, San Francisco, Cal., until 11 A. M., June 21, 1921, for furnishing the materials and labor of all kinds except as stated in the specifications necessary for the construction, equipment, completion and delivery of three, four and five second-class, single-screw, steel, steam-propelled light vessel No. 106 and type, for use on the Atlantic coast to an authorized representative of the Bureau of Lighthouses at their place of construction.

Drill Boat, New York—Bids will be received until noon, June 30, by the United States Engineer Office, Room 710, Army Building, 39 Whitehall street, New York, for constructing and delivering drill boat E. R. No. 1, which is to be used in conjunction with improvements in the East River. This boat is to have a steel hull, 140 feet long by 50 feet beam, and it is believed that the cost will be in excess of $500,000. Machinery and equipment will include two watertube boilers, to be equipped with an oil-burning system and having a working pressure of 200 pounds of steam with 50 degrees of superheat, four cargo winches, two steam-driven three-wire direct-current generating sets, each capable of delivering 10 kilowatts at 110 and 220 volts from a steam pressure of 100 pounds. There will be ten rock drill engines, of which eight are to be installed.

NEW INCORPORATIONS

The Delta Navigation Company, Stockton, Cal., has been incorporated, with a capital of $200,000.

The Interways Line, Inc., Wilmington, Del., has been incorporated, with a capital of $1,000,000, to own and operate boats.

The U. S. S. Milwaukee Company, Wilmington, Del., has been incorporated with a capital of $500,000, for salvaging ships, etc.

The Seven Seas Steamship Company, Inc., Wilmington, Del., has been incorporated, with a capital of $90,000, to own and operate boats.

The Ethiopian Steamship Company, Norfolk, Va., has been incorporated, with a capital of $350,000, by C. P. Madison, president, and Frank Johnson, treasurer.

The Munalbro Steamship Corporation, Wilmington, Del., has been incorporated with a capital of $500,000 to own and operate boats, etc.

The Atlantic Coast Port Service Corporation, Wilmington, Del., has been incorporated, with a capital of $100,000; wharfage and berthing of ships, etc.

The Terminal Operating Corporation, 142 Pavonia avenue, Jersey City, N. J., has been incorporated, with a capital of $100,000, to carry on a transportation and lighterage business.

The Gulf Transportation Company, Ltd., Quebec, Can., has been incorporated, with an authorized capital of $50,000, to own and operate ships for transportation of freight and passengers and to act as common carrier.

The Houston Tampico Steamship Company, Houston, Tex., has been incorporated with a capital of $1,000,000, by Arthur W. Britton, 65 Cedar street, Samuel B. Howard and Austin H. Smith, all of New York City.

The Merchants & Manufacturers' Transit Corporation, Rochester, N. Y., has been incorporated, with a capital of $100,000, by H. Barnard, 36 Main street, West Rochester, for trade, commerce and navigation.

The Southern Disappearing Propeller Boat Corporation, Wilmington, Del., has been incorporated, with a capital of $150,000, to manufacture and sell boats having disappearing propeller devices.

The Adams Boat Line, Sarasota, Fla., has been incorporated with a capital of $50,000 to build, purchase, sell, own, equip, lease, charter, and operate vessels, etc. J. E. Battles is president, John Savarese, vice-president; H. S. Smith, secretary and G. B. Prime, treasurer.

The Atlantic, Gulf & Mediterranean Steamship Company, Ltd., Montreal, Can., has been incorporated, with a capital of $250,000, to own, operate steam and other ships, wharves, dry docks, railway and ship terminals, etc., and to carry on the business of common carriers of passengers and goods. J. E. Grivell, E. M. Jackson, B. M. Rogers, P. Schramm and H. G. McKeil, Montreal, are the incorporators.

FOREIGN ACTIVITIES

Reederei A.G. Phönix, Hamburg, has been formed by a number of Hamburg and Cologne firms to engage solely in sea shipping.

Drydock, Cadiz, Spain.—Messrs. Echevarrieta y Larrinaga of Bilbao, owners of the shipbuilding concern, Astilleros de Cadiz, contemplate the construction of a dry dock at this yard.

New Shipyard, Hamburg, Germany.—The firm of Paul Theodor Berendsohn has leased from the state of Hamburg a site on the R. Kohlbrand for sixty years, for the purpose of establishing a shipyard to be known as the Kohlbrand Werft.

New Shipyard at Ghent.—A new shipyard has been opened at Ghent. At present only slipways for ships from 300 to 400 tons are ready. The plans, however, include slips up to 15,000 tons, and work is being carried on energetically.

Start Work on Ferry Slip, Vancouver, B. C.—The Board of Harbor Commissioners, Vancouver, B. C., is reported to have started the construction of the proposed car ferry slip on the Vancouver North Shore. The estimated cost of the slip is about $60,000.

To Improve Port, Genoa, Italy.—The officials of the Commune of Genoa and the Independent Harbor Consortium are reported to have drawn up a plan for the constitution of an organization to improve the port, which will raise a loan of 150,000,000 lire for the purpose.

New Shipbuilding Yard, Blyth, Eng.—At a meeting of the Blyth Harbor Commission, proposals were submitted in connection with the development of a new shipbuilding yard in the upper harbor, and a provisional arrangement reached with regard to the dredging line.

Ship Contract, Hamburg, Germany.—The Hamburg-American Line is reported to have contracted with the Blohm & Voss yards for the construction of three passenger steamers of 22,000 tons each, and eight steamers of 6,000, the latter to be equipped with Diesel engines.

Launchings.—The Ardrossan Dry Dock & Shipbuilding Company, Ltd., launched on April 27, the S. S. Laatefos, built to the order of Otto and Thor Thoresen, Ltd., of Christiania. She is 255 feet in length and of 2,650 tons deadweight capacity, and will be fitted with triple expansion engines.

To Construct Diesel Engines, Greenock.—J. G. Kincaid & Company are about to undertake the construction of Diesel engines on the Burmeister & Wain system, and have secured a sub-license from Harland & Wolff, which firm holds the sole license for Great Britain and its colonies for the construction of this type of engine.

The Palmer Shipbuilding & Iron Company, Hebburn-on-Tyne has launched the oil tank steamer San Gaspar, which was built to the order of the Eagle Oil Transport Company of London. The vessel is 548 feet in length and of 18,000 tons deadweight, and was built on the Isherwood system of longitudinal framing.

Launching, West Hartlepool.—The steel screw steamer Saint Denis, built to the order of the Société Navale de l'Ouest, Paris, was launched on April 22 by Messrs. William Gray & Company, Ltd. The vessel is 321 feet 3 inches in length, with a breadth of 46 feet 6 inches. The vessel is equipped to burn either coal or oil fuel.

Tonnage Output on the Wear.—During the month of April only two vessels were launched on the River Wear. This makes the total output for the four months of the present year nine vessels, with a total tonnage of 38,782 gross, compared with 22 vessels, with a total tonnage of 102,251, during the corresponding period last year.

Largest Motor Ship.—The Ocean Steamship Company of Liverpool (Alfred Holt & Co.) are understood to have a motor ship on order which will be the largest afloat. Her deadweight capacity will be about 15,000 tons, and she will have twin-screws, driven by Burmeister & Wain Diesel engines with a combined indicated horsepower of 6,400.

Launching, Pallion, Sunderland.—The steamer George M. Embiricos, built to the order of S. G. Embiricos, Athens, London and Cardiff, was launched at the yard of Short Brothers, Ltd. The ship has a length of 458 feet, a beam of 56 feet and a moulded depth of 30 feet 9 inches. She is constructed to meet the highest class of Lloyd's rules.

Hopper Vessels Ordered, Chepstow, South Wales.—The Monmouth Shipbuilding Company, Ltd., has secured orders for three single-screw hopper vessels, each to carry 1,000 tons, to be fitted with triple-expansion engines and high-class accommodation for officers, engineers and crew. The company has had plans prepared for equipping their yards for all classes of ship construction and engineering.

The single screw steel cargo steamer Frogner, which was built to the order of Fearnley & Eger, has been launched by Sir W. G. Armstrong, Whitworth & Company, Ltd. The vessel is 406 feet in length, and of 9,000 tons capacity with a speed of 11¼ knots. She has been built under special survey to meet the requirements of Lloyd's 100 A1 class and to conform to the rules of the Norwegian Board of Trade.

To Enlarge Port, Stockholm, Sweden.—The plans for enlarging the free port are now completed. The work is to be completed by July 1, 1925, and will cost about 30,000,000 kr. The area of the free port will be about 65 acres and the depth of water 30 to 33 feet. Two large piers, 1,150 feet and 1,480 feet in length and 55 to 62 feet in width, are to be provided. Together with the work already in hand the total cost of the port equipment will be 70,000,000 kr.

New Harbor, North Slesvig, Germany.—It has been proposed to build a new harbor in North Slesvig, which is to be arranged at the innermost port of the Hejlsminde Bay, where natural conditions are very favorable. For protecting the harbor two piers will be constructed and within the thus protected port which will have a depth of eight meters, one quay about two hundred meters in length is to be constructed, so arranged as to be extended by another 600 meters or more. This project will cost about one million kroners.

Morocco (French Zone).—A report from H. M. Consul-General at Tangier states that a new section of quay at Kenitra, 224 metres long, with open storage ground at the rear, has been authorized for contract. Two cranes to carry three tons each have been installed and are ready for service. The completion of existing work at Safi continues, also the preliminary work on the construction of the port for small barques. The port for small barques at Mogador is nearly completed with the exception of the clearing of the sandbanks, etc., for which purpose a dredger has been put into operation.

Docks, London.—The extension of the Victoria and Royal Albert Docks system, which the Port of London Authority have had in hand for so many years, is now nearing completion and expected to be formally opened on July 8. The new dock will have about 10,000 lineal feet of quayage, and part of the scheme provides for a dry dock 750 feet long and 110 feet wide to accommodate ships drawing up to about 35 feet of water. The new dock will have a water area of about 64 acres and an average breadth of 650 feet. The wet dock will connect with the existing dock by a passage of 100 feet spanned by a swing bridge.

Pier and Wharf, Vera Cruz, Mex.—It is reported that an agreement has been reached between the Mexican Government and an engineer covering a concession for the construction of a steamship pier and wharf at Vera Cruz. The wharf will have a length of 400 meters and a width of 100 meters, and will be constructed of stone and reinforced concrete. Warehouses and shelters adequate to handle merchandise passing over this wharf will be built, and it is calculated that seven ships can be handled at the same time. It is expected that the first half of the wharf will be completed and put to commercial use in about two years.

BUSINESS NOTES

The New York office of the Diamond Power Specialty Company has moved from 126 Liberty street to 90 West street.

The Chicago branch of the Lunkenheimer Company, manufacturers of engineering specialties, has moved from 188 North Dearborn street to 568 West Washington Boulevard, Cincinnati, Ohio.

The Power Specialty Company, manufacturers of Foster superheaters, economizers and oil stills, has opened additional offices located at 512 Reliance building, Kansas City, Mo., and 627 Linz building, Dallas, Tex. The Kansas City office is in charge of William F. Meyer and the Dallas office in charge of M. W. Brown.

The United States Shipping Board, under the Division of Operations, has opened an office at St. Louis, in the Liberty Trust building, which is the first inland office the board has established. Mr. T. Park is in charge of the new office. The purposes of this office are to establish a personal contact with the shippers of the Central Region, with a view to furnishing information as to trade routes and facilities of the American merchant marine at all ports.

The Western Electric Company and its exporting subsidiary, the International Western Electric Company, announce important changes in their executive ranks. Frederick Hayes Wilkins, European general manager of the International Company, with headquarters in London, has been elected a vice-president of his company. Mr. Richard Gregory, comptroller of the Western Electric Company, has been made a member of its board of directors. Mr. S. Wallace Murkland, who has been assistant comptroller of the American Company since 1918, is now general contract sales manager.

The interests and all patents and patent rights of the Duntley Pneumatic Tool Company have been acquired by the H. L. King Company, engineers and tool makers of Chicago, and Mr. King, president of the H. L. King Company has organized the Duntley-King Pneumatic Tool Company, an entirely new organization for the production of pneumatic tools and accessories. The new company has an organization and shop facilities skilled in the production of precision machine work and is now in production with general offices and factory at 1143-45 Diversey Parkway, Chicago, Ill.

George Oldham & Son Company, Baltimore, Md., manufacturers of pneumatic tools and appliances, announce the appointment of the following agents, who will carry a complete line of Oldham pneumatic tools, including chipping hammers, foundry hammers, riveters, scalers, holders-on, etc., as well as a complete stock of repair parts for all types of tools, in order to render prompt service to all concerns in their respective territories: Andrew-Mays Company, 505 Ellicott Square, Buffalo, N. Y.; Zorn & Barker, 80 E. Jackson Boulevard, Chicago, Ill.; J. R. Petley Company, 218 East Water street, Milwaukee, Wis.; H. B. Wilson Company, 915 Olive street, St. Louis, Mo.; Charles C. McGill, 702 Marquette building, Detroit, Mich.; George C. McKay & Company, 1046 St. Clair avenue, Cleveland, Ohio; Penn Machinery & Equipment Company, 2138 Oliver building, Pittsburgh, Pa.

TRADE PUBLICATIONS

Reilly Evaporator.—The Reilly self-scaling submerged type evaporator is described in detail in a pamphlet sent out by the Griscom-Russell Company, New York.

Census Takers of Industry.—The uses of automatic counters applied to all manner of machines are fully described and illustrated in a recent pamphlet issued by the Root Company, Bristol, Conn.

Lunkenheimer Valves.—A highly developed composite of the original Lunkenheimer valve construction principles, known as the "Ferrenewo" valves, is described in a pamphlet issued by the Lunkenheimer Company, Cincinnati, Ohio. Specifications and details of the construction, as well as price lists of various type valves, are given.

Pipe Stills.—A discussion of the main differences between the conventional tank still and the pipe still for refinery work is given in Bulletin 202 issued by the Power Specialty Company, New York. The catalogue includes a brief reference to the many advantages obtained by superheating the steam used in refinery work, and also notes and data of interest to refiners and pipe line officials on the flow of fluids in pipes.

Diesel Oil Engines.—A general review of the developments of the Fulton Iron Works Company, St. Louis, Mo., in the construction of Diesel engines, as well as a complete description of the four-cycle, A-frame construction embodied in the engine, is given in a catalogue recently issued by this company. The Fulton Diesel engine is based on the patents and designs developed by Franco Tosi, of Legnano, Italy, one of Europe's foremost builders of Diesel engines.

Curtis Steam Turbines.—The steam turbines of the Curtis type from 100 kilowatt to 3,500 kilowatt capacity, used for driving 60-cycle generators at 3,600 revolutions per minute, are described in Bulletin No. 42201-B issued by the General Electric Company, Schenectady, N. Y. Typical installations which have given excellent performance, as well as a detailed description of the construction of these turbines, are given in the catalogue.

Alloy Steels.—The methods of producing alloy steels are discussed in a non-technical way by G. Van Dyck, manager of the special steel department of the Joseph T. Ryerson & Company, Chicago, Ill., in a booklet recently published by this company. In detail, shop equipment, furnaces, heat treating processes, case hardening and testing of the steel are taken up in such a way that the average shop superintendent may select and buy the proper steel for any special work which he might have to handle.

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